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EDITORIAL.

ITEMS AND NOVELTIES.

Fairmount Water Works—New Wheels and Pumps.—The new wheel just started at the Fairmount Works is of the kind called "Jonval's Turbine." It is 10 feet 3 inches in diameter; the movable wheel having 49 buckets 17 inches deep and 21 inches wide. The power is transmitted through a bevel pinion of iron 5 feet 6 inches diameter, 18 inches wide on the face, working into a bevel wheel with wooden cogs 8 feet diameter, 18 inches face: this drives an iron spur pinion 5 feet diameter, 26 inches face, working into a spur wheel with wooden cogs 10 feet diameter, 26 inches face, fixed upon the main shaft, upon the ends of which are two crank-wheels 8 feet diameter, from which the pumps are driven. The main shaft is of cast iron, 25 feet 6 inches long, 18 inches diameter; the jour-

nals being 26 inches long, 15 inches diameter. The vertical shaft of the turbine is 10 inches diameter, 16 feet long, at the bottom of which is the stop upon which the wheel rests: this is made of lignum-vitæ, with the grain up; it is 17 inches diameter, and is kept constantly lubricated by a small stream of water from the reservoir.

The wheel is enclosed in a water-tight cast iron case, 12 feet diameter, and is provided with the usual draft-box and starting-gate common to wheels of this description.

The tail-race is provided with a drop-gate, so that it may be closed by raising this gate; the wheel-pit will then be pumped out by means of a centrifugal pump, driven by a small turbine 9 inches in diameter, supplied with water from ascending main, and will, therefore, have a head upon it of about 96 feet. By this arrangement, access can be had to the stop and gates of the wheel, should accident occur to them.

One disadvantage the wheel has to contend against is the variable head and fall under which it is required to work, ranging from 6 to 13 feet, as the tide rises or falls; this prevents the wheel giving as economical a result as it would with a constant head, as the wheel must be able to exercise its whole power at the minimum; it of course has too much power at the maximum head.

The wheel drives two double-acting force pumps of 22 inches diameter and 6 feet stroke; they are placed perfectly horizontal upon a continuous cast iron box bed-plate, which rests upon a granite foundation, the whole being secured to the solid rock by 2-inch bolts.

The water is taken into the pumps from the flume through two valve-chests, containing six brass clack-valves on each seat, placed at an angle of 45 degrees; these valves are of different sizes, the top ones having a clear opening of 5 by 16 inches, the next $5\frac{1}{2}$ by 16 inches, and the lower ones 6 by 16 inches; by this arrangement the valves do not close at precisely the same time, thus avoiding much of the shock usual upon pump-valves; the discharge-valves, are balanced tripple-beat cornish-valves.

The pumps are supplied from a wrought-iron flume, which also conducts the water upon the wheel; the inlet openings to the pumps are provided with cast iron gates, and the ascending main with a stop-cock; by shutting these, and disconnecting the connecting rod, either of the pumps may be thrown out of use, thus avoiding the

disadvantage of disusing both pumps when only one may be out of order.

The discharge-valves have air-chambers over them, 42 inches inside diameter, 7 feet high; the discharge-pipe from these two chambers are connected in a central air-chamber, 4 feet inside diameter, 10 feet high, from which passes a curved ascending main for each pump of 23 inches diameter, uniting by a breeches pipe in the ascending main proper, which is 36 inches diameter.

The pistons of the pumps are not packed in the ordinary way, but consist of cast iron cylinders, made as light as possible, somewhat like a broad driving pulley, the surface having a number of **V**-shaped grooves turned in it.

At the forebay end of the wrought iron flume are three cast iron sluice-gates, 5 feet high and 7 feet wide each, raised by screws and worm-wheel. The flume is of ¼-inch wrought-iron, with butt joints united by strong angle-iron ribs; it is 15 feet wide, 8 feet deep, and 24 feet long.

The speed of the pumps is intended to be 13 revolutions per minute; they will then have a capacity to raise 8,631,360 United States standard gallons per 24 hours.

The two breast-wheels taken out to make room for the turbine, could only raise about 2,836,080 gallons. The new wheel will, therefore, raise three times the quantity, and with a consumption of something less than 10 per cent. more water.

The ascending main, after it leaves the mill-house, passes over the forebay at a height of 9 feet above the level of the dam; it is of flanged pipes, 36 inches diameter, suspended by wrought-iron suspensions bars, 10 inches wide, 1½ inches thick. These are attached by bolts and lugs to the top of the end pipes; the main thus forms its own bridge, the pipe itself being the top chord.

The clear span is 77 feet 11 inches; the total deflecture of the main when filled with water, and in use, is found to be $\frac{7}{16}$ths of an inch. After crossing the forebay, the main rises into the reservoir at an angle of about 43 degrees. Its total length from the pump to its discharge in the reservoir is 246 feet. Upon the upper end, which enters the reservoir a few feet below the ordinary surface of the water, is placed two clack-valves, at an angle of 45 degrees, in order to prevent the return of the water, should accident occur to the main.

The designs for the whole arrangement of the work—the pumps,

flumes, head-gates, the alteration of the mill-house, and the suspended main across the forebay—were made by the Chief-Engineer of the Water Department, Frederick Graff.

The design for the wheel and its gearing are by Emile Geylin, the contractor for the construction of the whole work. Mr. G. was the first to practically introduce the Journal Turbine into this country, and has been eminently successful with all the numerous wheels he has erected. The sub-contractors under Mr. G. were, for the pumps, bed-plates and connecting-rods, I. P. Morris & Co.; for the large wheel-case, the gearing, with its shafts and crank-wheels, the West Engine Co., of Norristown; the head-gates and the wrought-iron flume were made by Hunsworth & Naylor; and the turbine, and its fixtures, at the shop of Mr. Geylin.

Working of Steep Gradients.—An interesting paper on the Mauritius Railways was read before the Institution of Civil Engineers on the 2d of February, by Mr. J. R. Mosse, C. E., in which a full detail was given of the structure and working of the two railways which had been constructed in this locality.

The two lines were named, respectively, the North Line and the Midland Line.

The character of the gradients on the Midland Line will be understood from the following summary: From Port Louis to the summit there was a rise of 1817 feet in a distance of about sixteen miles, making an average gradient of 1 in 46·68. From the summit to Mahebourgh, a distance of about nineteen miles, the rate of descent was 1 in 55·61. For about twelve and a half miles before reaching the summit, the rise was 1 in 41·17, and from the summit, for about thirteen and a half miles, the fall was about 1 in 45·06.

The steepest gradient was 1 in 27, of which there was a total length of 13,526 feet, the greatest continuous length being 6163 feet, and the next 5016 feet. The next in severity was 1 in 30, of which there was altogether 9526 feet, the greatest continuous length being 3000 feet. The curves varied from 950 feet to 6000 feet radius, and in length from 200 to 3200 feet, the ordinary radii being 2000 and 3000 feet. The shortest radius occurring in the sharp gradients of 1 in 27 and 1 in 30, was 1600 feet, of which the greatest continuous length in the former was of 1930 and in the latter of 900 feet. The next in severity was with a radius of 2000 feet on the gradient of 1 in 27, the greatest continuous length of this being 1000 feet. Reverse curves of this radius were also found,

1920 feet in length, on the same gradient. On descending from the summit to Mahebourgh, the distance between the seventeenth and nineteenth mile might be considered as composed entirely of reversed curves.

The locomotives first used on this line, seven in number, had cylinders 16 inches in diameter, 22 inches stroke; the wheels, six in number, were 3 feet 6 inches diameter, and were all coupled, giving a wheel base of 15 feet. The weight of these engines, with fuel and water, was about 37 tons, and they were worked with 120 pounds steam pressure. Subsequently, six larger engines were designed by Mr. Hawkshaw, having the following dimensions: Cylinder, 18 inches in diameter, with stroke of 24 inches. The wheels, eight in number, were 4 feet in diameter, and all coupled, giving a wheel base of 15 feet 6 inches. The centre pair of wheels, which were the drivers, were fixed rigidly on the frame, but the leading and trailing wheels had $3\frac{3}{4}$ inches play in their journals, and the connecting rods between these and the driving pair were fitted with ball and socket joints.

These engines, with fuel and water, weighed 48 tons each. These engines took five passenger cars and one break van up the inclines, making a load of 42 tons, and sometimes even eight cars, equal to 56 tons, while of goods, the usual load for the smaller locomotives was 70, and for the larger 100 to 120 tons.

Average speed for passenger trains, including stops, was 12 miles per hour; for goods, 9 miles per hour on the up grades.

On one trip, where everything was carefully noted, the results were as follows: Ten loaded cars, weighing, together, 83 tons, were drawn, which, with the engine, made a gross load of 131 tons. The average speed was eleven miles per hour, and, taking the average pressure of steam in the cylinders as 60 pounds per square inch, the power exerted would be $\frac{131 \times 11 \times 88}{33{\cdot}000} = 230$ H. P., or, not including the weight of the engine, 146 H. P., and this divided by the weight of the locomotive, was 3·04 H. P. per ton of motor. The coal used was from Sidney, N. S. W., and the consumption amounted to 4·75 pounds per H. P. per hour, eight pounds of water being evaporated by one pound of coal, but ordinarily only seven and a half pounds of water were evaporated by each pound of coal.

All the carriages but the first-class ones had a break on each

wheel worked from inside. Clark's continuous break, which operates all the breaks in the train at once, has been used with great success, and each break was provided with sand boxes, leading to the rails; as before, the dew on the rails prevented their proper action. Fortunately, no accidents had occurred from trains getting beyond control on the heavy grades, although some narrow escapes had been made. Thus, on one occasion, the rails being wet, a train descended from the summit, a distance of three miles and three-quarters, in five minutes.

The working expenses thus far had been 62½ per cent. of the gross receipts, owing to exceptional conditions of irregular traffic, &c.

As a conclusion drawn from three years' experience with this road, the author of this paper had concluded that, although it might sometimes be impossible to construct a railway with easier gradients than those of this road, yet the difficulty of working in wet weather, the small loads carried, and high speed attained, rendered such inclines undesirable, even though a very great outlay was required at first to avoid them. In fact, the severest grade which should be adopted was 1 in 40. It was also suggested that in laying out such inclines, whatever might be the ruling gradient should be adhered to, as far as practicable, throughout, and that pieces of level should be introduced between the different inclines, as they were of the greatest value in controlling trains in descending.

Suez Canal.—The following figures show the condition of the work on the canal on 1st January, 1869: also the progress made during the past year. The two exhibits taken together, may give us the data for calculating the time when the entire work will be completed.

The estimates of quantities are given in *cubic metres*, to which 37 per cent. should be added to show the results in *cubic yards*.

The aggregate amount of earth to be moved, to dig the canal according to the plans adopted, was 74,112,130 cubic metres; of this there remained on 1st January, 1868, 40,000,000 cubic metres yet to be done.

During the past year the progress has been as follows:

First quarter	4,507,956
Second quarter	5,519,808
Third quarter	6,234,013
Fourth quarter	6,889,669
	23,151,446 cubic metres.

Leaving less than 17,000,000 cubic metres to be moved on the 1st January, 1869. The time now named by Mons. Lavalley for the entire completion of the work is 1st October next, and there seems to be no reason to doubt his ability to make good this prediction.

The success of the dredging machines has been even beyond the anticipations of their strongest advocates. One machine is credited with 108,000 cubic metres of excavation, in a single month; another with 88,889; another with 78,056 cubic metres within a like period. They have double gangs of men, and work night and day. Six dredges in November, in the Port Said division of the canal, raised 313,628 cubic metres; three other machines, at Ras-el-Ech, raised 214,042 cubic metres. The last new dredge of the contractors was put at work in December; and now their entire force, 60 machines, is being driven to its utmost capacity, in order that the canal in its full dimensions may be opened to the commerce of the world with the least possible delay. The piers or jettys at Port Said are entirely finished. The western pier was completed on 8th September, and the making of the concrete blocks was stopped the same day. On 15th December there remained but 316 blocks to be sunk to finish the eastern pier; and these could easily be handled in ten days.

The harbor and basins at Port Said have been dredged to a depth throughout of 23 feet; and now the French, Russian, Austrian and Egyptian steamers touch there regularly. No difficulty is experienced in running into this harbor at any time of day, or in any weather; whereas, at Alexandria, no vessel drawing 15 feet ever attempts to enter except by day light; and in heavy weather, steamers have been obliged to wait outside the bar for two and three days, on account of the narrow, shallow entrance to the harbor.

During the first six months of last year 513 vessels entered at Port Said, landing 3282 passengers, and 105,832 tons of merchandise. The viceroy of Egypt has ordered the line of railway between Cairo and Suez to be abandoned; and a new line of railroad has been constructed from Alexandria and Cairo to Suez, by way of Zagazig and Ismailia. This new route was opened in November last; and henceforth, Ismailia will be the stopping place on the Isthmus for passengers between Europe and India, while waiting for their steamers either in the Red Sea or the Mediterranean.

Adjustable Hanger, by James W. Loraine.—At the last

meeting of the Franklin Institute there was exhibited the hanger shown in Figs. 1, 2 and 3, manufactured by Wood, Loraine & Co., of this city.

Fig. 1.

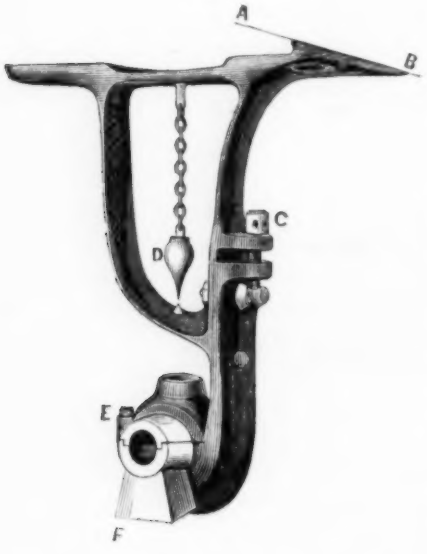


Figure 1 shows the apparatus entire, while Figures 2 and 3 show the upper and lower portions, respectively, detached from each other.

The straight edge, A B, is made exactly parallel with the axis of the journal, and the point of suspension and "sight point" of the plumb line, D, are exactly at right angles with this line, and in line with the centre of the journal.

This facilitates the setting of these bearings, as by drawing a line on the ceiling or girders parallel to the proposed line of shafting, setting the straight edge, A B, upon this, and then making the frame plumb by its own plumb-line, several of the

Fig. 2.

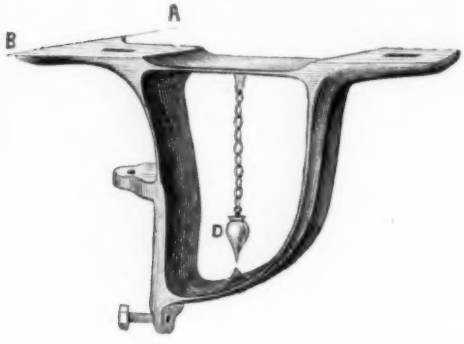
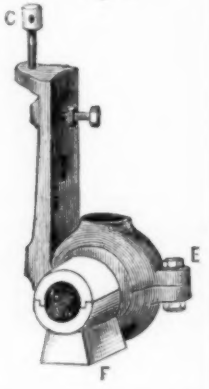
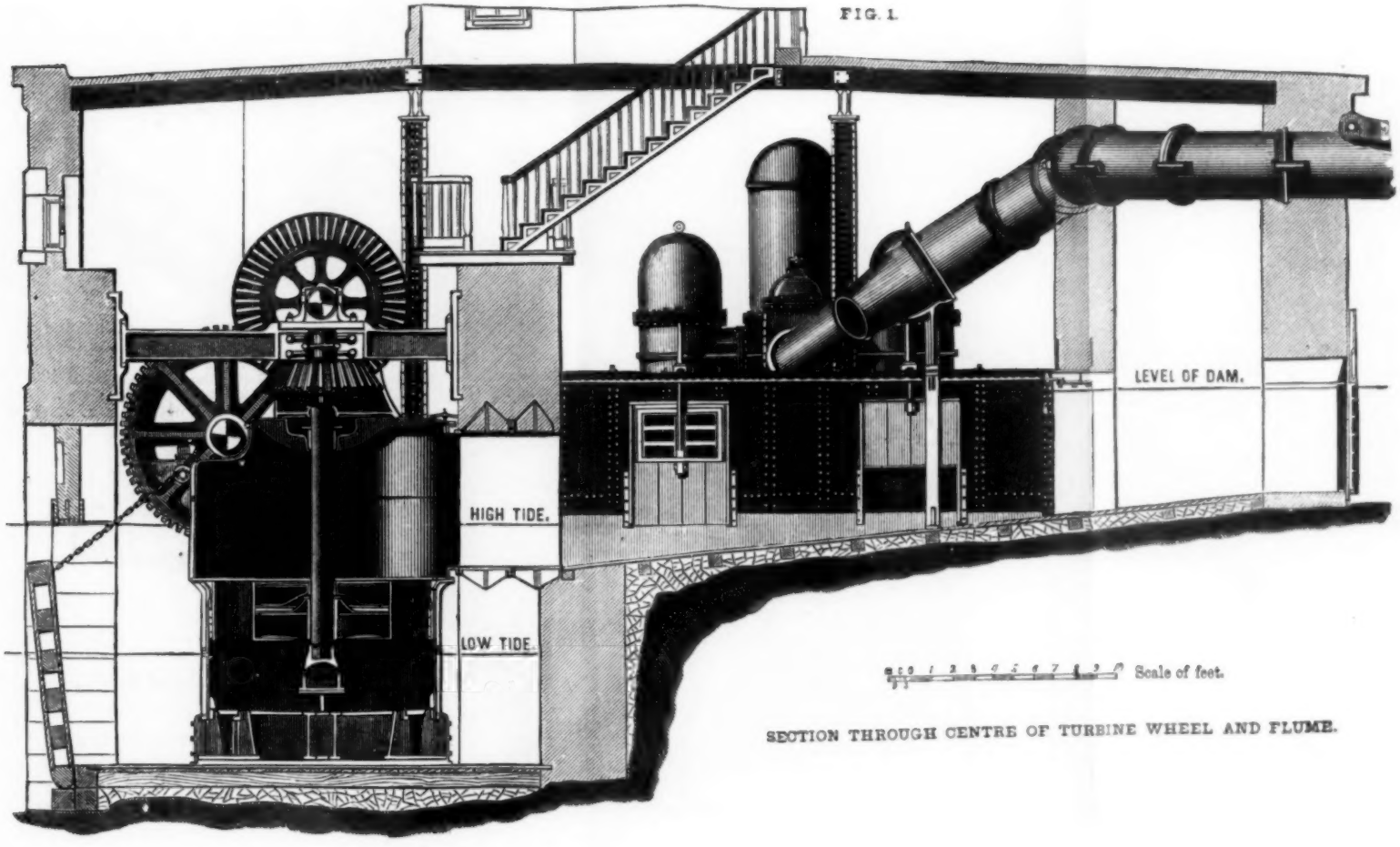


Fig. 3.



inconveniences attending the adjustment of ordinary hangers are avoided. Thus the stretched line for the centre of the shaft is dispensed with, as well as the various inconveniences accompanying its use.

FIG. 1.



SECTION THROUGH CENTRE OF TURBINE WHEEL AND FLUME.

After these upper parts are all in place, the lower portions are attached, the necessary vertical adjustment being obtained by means of the bolts passing through vertical slots shown in the cuts.

A great advantage is claimed for this hanger in case of erection, since the greater part of the weight is not attached until the setting of the upper portion is finished; and also because the entire enclosing of the socket gives it special advantage where exposed to severe side strains. The plumb and index point being always attached and in sight, show at once any deflection from line in their direction, when such occurs.

The Mont Cenis Tunnel.—During the past year an advancement of 1,320·15 metres has been made at the Mont Cenis tunnel, of which 638·60 was driven on the Italian side, at Bardonnêche, and 681·55 metres on the French, at Modane.

The following shows the monthly advancement, in metres, made during 1868:—

	Progress made at		Total advancement made during month.
	Bardonneche	Modane.	
January	54·30	51·90	106·20
February	49·00	47·05	96·05
March	49·30	60·85	110·15
April	46·90	62·45	109·35
May	61·30	54.50	115·80
June	59·80	54·15	113·95
July	63·90	64·80	128·70
August	52·10	56·80	108·90
September	50·00	56 85	106·85
October	52·20	63·25	115·45
November	56·10	61·85	117·95
December	43·70	47·10	90·80
Lengths driven during 1868	638·60	681·55	1,320·15
Lengths driven previous to 1868	4,724·50	3,122·15	7,846·65
Total lengths driven	5,363·10	3,803·70	9,167·80
Remaining to be driven			3,053·20
Total length of tunnel			12·220

This gives an average advancement of 110 metres per month, or 53·20 on the Italian side, and 56·80 on the French; and at this rate

of progress the time necessary for the completion of the tunnel would be 28 months, or about April, 1871, and for opening the railway about six months more, or in less than three years from the present time.

The following Table shows the yearly progress that has been made with these works since their commencement in 1857:—

YEAR.	Bardonneche	Modane.	Total Advancement.		Expenditure.
			Each Year.	At end of Year.	
	metres.	metres.	metres.	metres.	francs.
1857 } 1858 }	284·85	212·75	497·60	497·60	3,369,000
1859	236·35	132·75	369·10	866·70	1,630,000
1860	203·80	139·50	343·30	1,210·00	3,000,000
1861	170·00	193·00	363·00	1,573·00	2,500,000
1862	380·00	243·00	623·00	2,196·00	2,000,000
1863	426·00	376·00	802·00	2,998·00	3,500,000
1864	621·20	466·65	1,087·85	4,085·85	6,552,000
1865	765·30	458·40	1,223·70	5,309·55	5,502,000
1866	812·70	212·29	1,024·99	6,334·54	5,644,000
1867	824·30	687·81	1,512·11	7,846·65	6,000,000
1868	638·60	681·55	1,320·15	9,166·80	7,500,000
	5,363·10	3,803·70	9,166·80	.....	47,197,000

Ellershausen Iron.—Much interest has been of late excited on the subject of a new process for the manufacture of wrought from cast iron, invented by Mr. Francis Ellershausen, of Pittsburgh, Pa. The process consists, essentially, in mingling together streams of melted cast iron and pulverized iron ore as they run into moulds, and then heating the conglomerate in a reverberatory furnace to a welding temperature, when it may be taken out, squeezed and forged, without other working in the furnace, and so produces iron of an excellent quality, with a greatly reduced cost of labor and fuel.

The exact method of procedure is as follows:

On the casting floor of the smelting furnace, a cast iron turn-table about 18 feet in diameter is revolved on rollers by a small steam engine. Upon the outside edge of the table stand a row of cast iron partitions, forming boxes, say 24 inches wide and 10 inches high, open at the top. Just above the circle of boxes stands

a stationary, wide-mouthed spout, terminating in the tap hole of the furnace. When the furnace is tapped, the liquid iron runs down this spout and falls out of it in a thin stream into the boxes as they slowly revolve under it, depositing in each a film of iron, say one-eighth of an inch thick. But before the fall of melted iron reaches the boxes it is intercepted, or rather crossed at right angles by a thin fall of pulverized iron ore, which runs out of a wide spout from a reservoir above. These two streams or falls are of about equal volume.

The thin layers of iron and ore at once chill and solidify, so that by taking out the outer partition of the boxes (which form the rim of the turn-table,) they may be removed in cakes of the size of the boxes, and weighing about one hundred pounds each. These cakes or blooms are put into a reverberatory puddling or heating furnace, and raised to a bright yellow heat. They will not melt at this heat, but become softened so as to be easily broken up with a bar. The blooms are formed in the furnace, by the "rabble" of the workmen, as in ordinary balling operations. The balls are brought out, one after another, squeezed in the ordinary "squeezers" to expel the cinder and superfluous ore, and then rolled into wrought iron bars, which are now ready for market, or for further reduction into smaller finished forms.

The essential features claimed are: First, that a conglomerate of iron and oxide such as is produced by the first step in the process, will not melt when submitted to the heat of a puddling furnace. Secondly, that the reaction which takes place between the intimately mingled iron and oxide in this last condition, suffices to remove impurities from the substance in such a way as to develop a first-class iron from good material, and as good a product as can be obtained by the ordinary process of puddling from inferior grades of ore and pig. The local papers speak in the highest terms of this process, and time alone is needed to settle the question of its actual value. The connection of this process with the theory lately advanced by Mr. Siemans, regarding the part played by the fettling in ordinary puddling, is worthy of notice. See this *Journal*, Vol. LVI, p. 252.

The patent by which this process is covered specifies as follows. "That the novelty or invention claimed consists in the mixing of solid oxides into and among fluid cast iron, or of fluid oxides with solid cast iron, granulated or minutely subdivided, in such a manner and in such quantity as to produce a solid conglomerate of the

SIDE ELEVATION OF FORCE-PUMP.

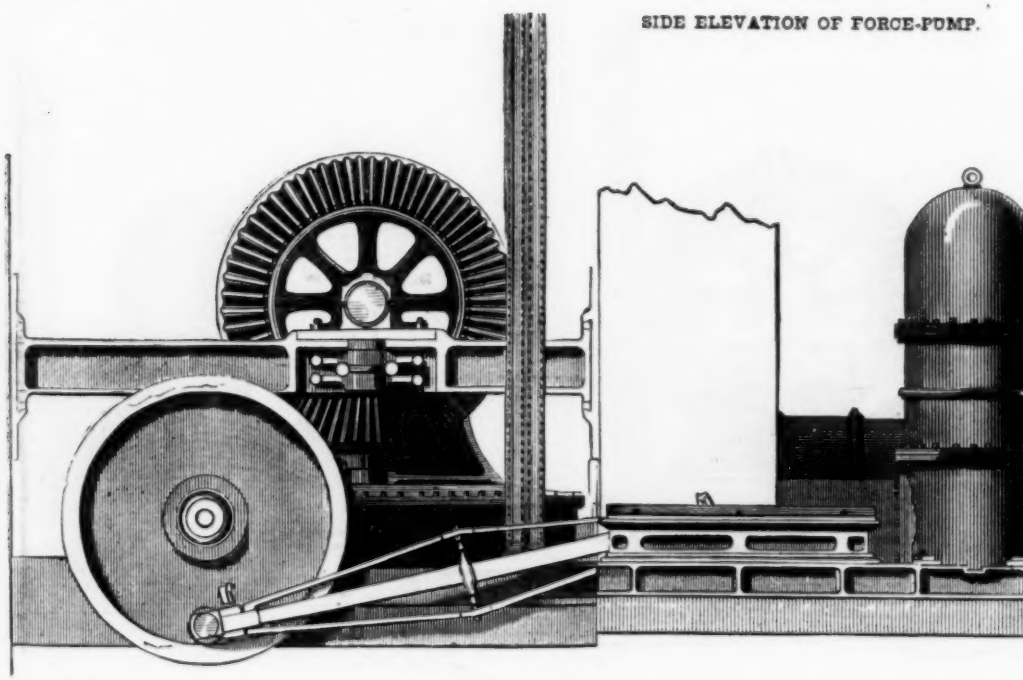
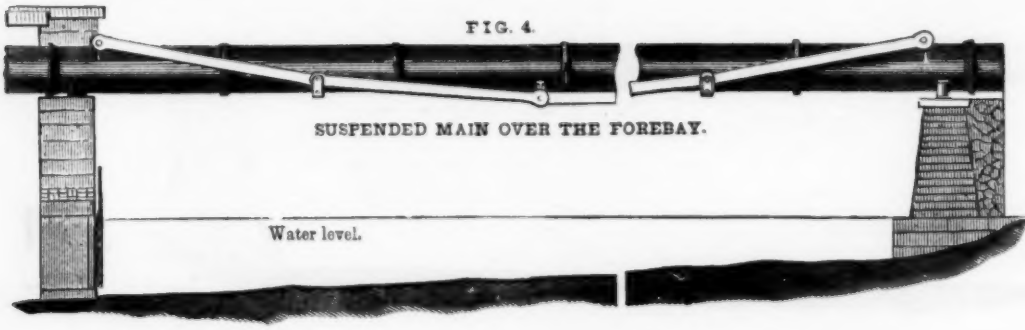


FIG. 4.

SUSPENDED MAIN OVER THE FOREBAY.



RCE-PUMP.

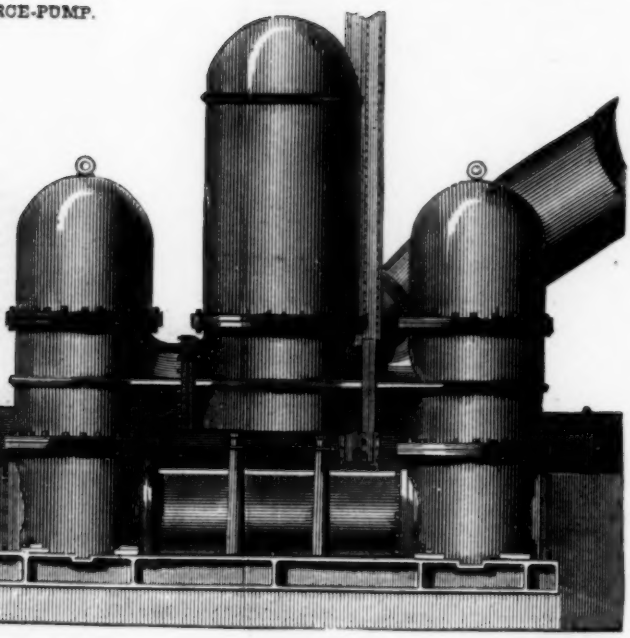


FIG. 6.

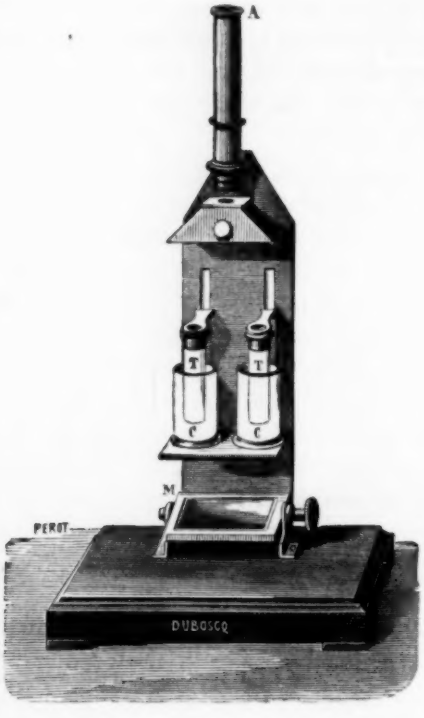
FIG. 6.

SECTION OF SUSPENDED MAIN.

two substances, and also in effecting this mixture, and producing the resulting pig bloom or pig scrap, without the application of other heat than that of the fused cast iron or oxide, as the case may be, thus dispensing with the use of a furnace for any part of the process of mixing after the melting of the cast iron or oxide, whichever of them is used in a fused condition.

The material thus produced may be used in like manner as any wrought iron of similar shape, so that when raised to a welding heat, the pig bloom, manufactured as hereinbefore described, may be pressed, squeezed, hammered, rolled, or worked in any of the methods employed in the treatment of wrought iron, and with like results, excepting that the article of wrought iron produced by this process is superior in quality to that obtained in the ordinary way.

Duboscq's New Colorimeter.—M. Duboscq has submitted to the Academy of Sciences his new colorimeter for measuring the differences of tint in solutions. The following description we find in Les Mondes. The two liquids are placed in the two cylindrical vessels, G G′, of glass, fixed side by side, before the vertical shelf of the colorimeter.



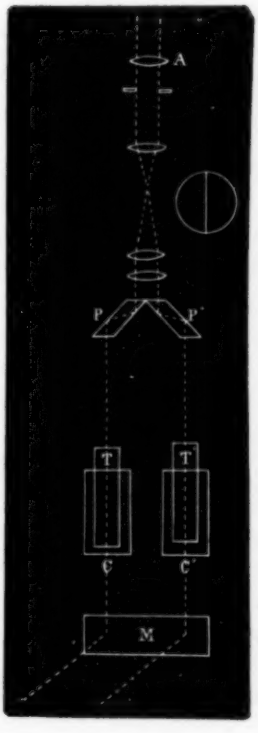
In the two vessels, two tubes of smaller diameter, T T′, closed at the lower extremity by a disc of glass, may be raised and lowered by means of the movable pinions engaged by two racks cut into the vertical table. To each pinion is fastened a vernier, which is moved under a graduated scale, and which measures the distance between the bottom of the vessels and the lower disc of the movable tube.

The luminous rays transmitted by the two columns properly illuminated by a mirror, M, placed above, and moved

around in a horizontal axis, suffer each two reflections, within one of Freswel's rhombs, P P′, and then arrive in the same field of vision, in such a manner that each shall illuminate the half of the field with a semi-disc or circle of yellow color, more or less intense. These colors are observed with a small lens, which is nothing but the base of a terrestrial eye-piece, formed of four glasses, and which magnifies sufficiently, so that the field may be illuminated by the colored plates with perfect uniformity.

The colors are proportional to the height of the columns if the liquid contain the same proportion of caramel; or proportional to the richness of the liquid in caramel, if the two columns have the same height.

In the last case, if we cause the height to vary, we have the same shade on these two semi-discs.



Suppose that the standard solution is in the cup to the right, and that we lower the interior disc or movable tube to 20 millimetres from the bottom of the cup; we will thus have a column of 20 millimetres, which gives to the half disc of the left hand side a pale yellow coloration. Admitting, then, that the half disc at the right has the same coloration, but that the column of the liquid placed in the cup to the left, has not a height of 40 millimetres, this informs us that the solution to be tried contains a proportion of caramel more than that contained in the standard liquid.

In fact, for the same color on the two semi-discs, the proportions of caramel contained in the two liquids are inversely as the height which we give to the column of the liquids.

One hundred centimetres of the solution tried, contained, then, in the case we speak of, $\frac{0 \text{ gr. } 2}{2}$ of caramel.

If we have dissolved, for example, 10 grammes of syrup in 100

cubic centimetres of water, we should know that 10 grammes of the syrup contained one d. c. g. of caramel.

Fall of a Chimney Stack.—Early on Sunday morning a chimney stack, 100 feet high, connected with the paper mills at West-end, Glasgow, fell during the gale. Near the base of the stack were a row of cottages, the roofs of two of which were crushed in, and the sleeping inmates buried in the ruins. Seven persons were killed on the spot, and another died in the course of the afternoon. *Engineering, Feb.* 19.

The Metal Hydrogen.—At a late meeting of the Royal Society, as we learn from the *Athenæum* of January 16th, Graham presented a specimen of Palladium, charged with some 800 or 900 times its volume of hydrogen, by some process which is not described in the above journal, but which, from his previous researches (see this *Journal*, Vol. LIV., p. 16, and Vol. LVI., p. 79), we presume consisted in heating it in an atmosphere of compressed gas. This specimen was accompanied by a paper, in which it was explained that the variations of density, of conducting power, &c., produced in the Palladium by the absorption of the hydrogen, seemed to indicate that a true alloy had here been formed, and thus to establish the metallic character of the consolidated gas. Various rumors of this circumstance have been circulating in our daily papers, in which the specimen presented by Mr. Graham was exalted into "an ingot of hydrogen," and though in comparison with this, the actual fact may seem disappointing, yet in its true relations it is sufficiently wonderful, and is certainly a decided step towards the not impossible realization of the veritable "ingot" at some future time. As a mere evidence of the intensity of molecular force, this experiment of Graham reaches into the marvellous and the incomprehensible. If the space occupied by the condensed hydrogen had been entirely void of all other matter, the force required to reduce 800 volumes to 1 volume would have been 800 atmospheres, or 12,000,000 pounds to the square inch, but with a metal like Palladium, as dense as lead, it would be a large allowance to suppose that $\frac{1}{1000}$th part of its volume were void space, or consisted of the instertices between its particles. To compress the eight hundred volumes into this bulk would then demand a force of *twelve million pounds*, or *six thousand tons per square inch.* Yet this inconceivable force is quietly exerted by the atoms of Palladium in their attraction for those of the hydrogen.

This substance, hydrogen, has other evidence of its metallic character beside these experiments of Graham. We do not allude to

its chemical and electrical connections with the metals, but to an action closely related to this absorption by Palladium, which, though for some time known, presents a new aspect when viewed in the light of this result.

In 1863, Dr. Charles M. Wetherill made a series of investigations on the Ammoniacal Amalgam, which very clearly demonstrated that the peculiar compound known by that name was not an alloy of any such compound as NH_4 with mercury, but was, in truth, a "suds" of mercury, frothed up with minute bubbles of hydrogen and ammonia, but yet holding the gas in such close union as evidenced a decided affinity between the two bodies. (*Silliman's Journal*, Vol. XL, p. 160). We might then justly consider this attraction for and retention of the hydrogen by the mercury, as being analogous to the infinitely more energetic action which is shown by Palladium, and like it, also, as indicating a tendency in the hydrogen to alloy itself in the manner of a metal with other metallic elements. Remarkable as is this element in its chemical relations, it is equally notable in another respect, about which a few words may be appropriate (in connection with the late astronomical discoveries of which we have recently spoken), under the head of

The Cosmical Relations of Hydrogen.—When Miller and Huggins attacked, with the Spectroscope, the problem of the constitution of the nebulæ, which had successfully defied the most diligent telescopic research, and had demonstrated that many of these were of gaseous consistency, hydrogen was one of the substances first recognized in the wonderful nebula of Orion and in several others. Now, this nebula of Orion was believed by Lord Ross to have been completely resolved by his telescope into separate points of light,* and we should thus be led to conclude that it is, in fact, a vast system—an universe—of suns or luminous centres, none of them solid, however, but all, on the contrary, vast spheres of glowing gas, that gas being chiefly hydrogen, mixed with nitrogen.

When, in May, 1866, a star in the constellation of the northern crown suddenly burst forth with unprecedented splendor, and when examined with the spectroscope showed a spectrum such as had never before been encountered, consisting of such an one as our sun or an ordinary star gives, but with four bright lines, due to a gas-

* He says (*Cosmos*, Vol. IV., p. 306, Bohn's edition): "I think I may safely say there can be little if any doubt of the resolvability of this nebula. * * We could plainly see that all about the trapezium was a mass of stars."

eous source of light, superposed, it was found that two of these lines (and those the most brilliant) were such as come from light emitted by intensely heated hydrogen. The natural conclusion from this was, that some half extinguished star or sun had been encountered by one of these nebulous masses of hydrogen, or else by some vast globe or planetary cloud of the same gas, which had lost its heat and ceased to be luminous. This true "planet" or "wandering sphere" of hydrogen, coming within range of the star's attraction, was drawn down to it, and by the arrest of motion and compression consequent upon its encounter, was itself heated to incandescence, and heated also the surface of the dead sun to a temporary but intense brightness.

Here, then, was presented the spectacle of a world on fire, in which the agent of destruction, or reconstruction, whichever it might be, was one of these celestial masses of hydrogen gas.

It is curious to reflect in this relation that, making due allowance for the probable distance of this star and the velocity of light, this sphere had been at rest for some ten or twelve years after its fiery ordeal, at the time when we witnessed the event as in actual progress.

When, about a year since, Graham subjected pieces of meteoric iron to the same treatment which had, in the case of ordinary iron, eliminated the carbonic oxide which it had absorbed while undergoing fusion in the smelting furnace, it was hydrogen gas in large quantity which was evolved, thus proving that in the furnace in which these "falling stars" were fused and cast into shape, this same widely distributed element was again predominant.

Lastly, in those spectroscopic observations and discoveries in connection with the sun, which we described in our last number, it seems to be very clearly shown that hydrogen gas is again the main constituent of that, which Lockyer proposes to call the solar "chromosphere," which surrounds the entire mass of our luminary for a depth of some five thousand miles, and forms those flames or protuberances, a single tongue of which, as in the last eclipse, may contain some 7,000,000,000,000 cubic miles, or twenty-seven times the Earth's volume of this gas.

We have reason, therefore, to wish that our knowledge of these solar appendages may not become *too* intimate, and that none of them may, by an excursion to this distance, furnish to other planets, at our expense, a second display of the phenomena exhibited in τ Coronæ Borealis.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES NO. II.

By J. H. Cooper.

(Continued from page 92.)

Superiority of the Driving Belt.

"There is no simpler or smoother means of communicating motion than that afforded by the noiseless agency of cords, bands or straps. The very means by which the motion is maintained, namely, by the frictional adhesion between the surfaces of the belt and the pulley is a safe-guard to the whole mechanism, as, if any unusual or accidental obstruction should intervene, the belt merely slips, and breakage and accident are thus prevented."—*Lond. Mech. Mag.*, Mar. 1863.

"The facility with which this communication of rotary motion may be established or broken at any distance, and under almost every variety of circumstance has brought the band so extensively into use in machinery, that it may be considered as one of the principal channels through which work is made to flow."—*Moseley.*

Care of Belts.

In order to have belts run well, they should be perfectly straight and be of equal thickness throughout their length, have but one laced joint; but if circumstances require any belts to be composed of several pieces, the ends should be evenly beveled, and united by one or other of the permanent ways already mentioned. The ends to be laced should be cut at right angles with the sides, the lace holes formed by an oval punch, reducing the cross-section of belt the least, and the lacing put in evenly, of equal strength at the edges of the belt, and no crossing of laces on the inside. If copper, or other rivets, are used, the heads should be "let in" rather below the level of the inside surface of the belt to prevent contact with the pulley, and the washers placed on the outside surface. If the beveled and lapped ends are sewed, the waxed ends should be "laid in" flush on the inside of the belt to prevent wear.

Belts and pulleys should be kept clean and free from accumula-

tions of dust and grease, and particularly from contact of lubricating oils, some of which permanently injure the leather.

Quick motion belts should be made as straight and as uniform in section and density as possible, and endless if practicable, that is, with permanent joints.

Horizontal, inclined and long belts give a much better effect than vertical and short ones, and those which have the driving side below than otherwise.

Belts which run loose of course will last much longer than those which must be drawn tightly to drive; tightness being evidence of overwork and disproportion.

Tighteners should never be used, but when they must be, they should always be as large in diameter, and as free running as can be, and should be applied to the slack side of belts.

The most effective tightener is the weight of the belt on its slack side, which increases adhesion by increasing circumferential contact with the pulleys.

"Belts which run perpendicularly should be kept tightly strained, and should be of well-stretched leather, as their weight tends to decrease their close contact with the lower pulley."—*Hoyt Bros.*

"Belts of *coarse*, *loose* leather will do better service in dry, warm places; for wet or moist situations the *finest* and *firmest* leather should be used."—*Hoyt Bros.*

"Care should be taken that belts are kept soft and pliable. The question is often asked, 'what is best for this purpose.' We advise, when the belt is pliable, and only dry and husky, the application of blood-warm tallow; this applied and dried in by heat of fire or sun, will tend to keep the leather in good working condition; the oil of the tallow passes into the fibre of the leather, serving to soften it, and the stearine is left on the outside to fill the pores and leave a smooth surface."

"The addition of resin to the tallow for belts used in wet or damp places, will be of service, and help preserve their strength. Belts which have become hard and dry, should have an application of neat's-foot or liver oil, mixed with a small quantity of resin; this prevents the oil from injuring the belt and helps to preserve it. There should not be so much resin as to leave the belt sticky." *Hoyt Bros.*, N. Y.

Substitutes for Leather Belting.

"A contemporary says that the improved steel wire has a strength of from 160 to 175 tons per square inch of actual section; that 176 No. 14 wires have a total section of one square inch, and that each wire will bear from 2,000 to 1 ton leaking strain; and that the ropes made from these wires run readily around 4 feet or 5 feet drums, coil perfectly, and last for a long time. Such being the case it becomes important to us to look to steel, in a measure, to substitute leather driving belts." . . . . . .

"While the substitution of leather by other substances, such as the vegetable gums, gutta-percha and india-rubber, impregnated into strips of coarse woven fabrics, has often been tried, and used, too, with a certain measure of success. Speaking as we now do, from an experiment as to the value of such a combination for driving belts, we can certainly assert that we never found them one-quarter as durable as leather; their use was more costly than the older used substance."

. . . . . "In some, though few cases, iron and steel wire belts have been used, the pulleys on which they run being covered with buckskin or some other leather, to increase the adhesion."

"We have cited these few remarks to throw out the hint that, now when cheap and strong steel wire can be purchased, there promises to be a fruitful field for inventive talent to devise some means of so weaving steel wire and gutta-percha into flat belting, producing a stronger and better adhering driving band than leather ever can be."—*Prac. Mech. Jour.*, Nov., 1867, p. 237.

Chas. Sanderson, of Sheffield, England, has taken out a patent—dated Dec. 8, 1862—"For making driving bands of thin sheet metal, coated with rubber to prevent oxidation." "The bands are first well cleaned with acids, then coated by electro process with brass, after which they are coated all over with gum vulcanized thereon, and which adheres tenaciously to the metal coating. Bands of great strength may be made by cementing together several made as above, with a layer of gum between each, the gum imparting flexibility and adhesion to the compound band in passing over the pulleys."

George and Daniel Spill, of Middlesex, England—under date of Nov. 9, 1859—have taken out a patent for "the manufacture of bands by weaving together covered strips of metal with ends of hemp or other fibrous material."

"A strip, or band, or wire of steel is covered with one or more strands of hemp cord, previously passed through a solution of caoutchouc, gutta-percha, glue, drying oils, gums, resins, tar, pitch or other glutinous, gelatinous or siccative materials. After the strands have been applied, the strip or wire is passed between rollers, in order to solidify the covering.

Any required number of metal strips or wires thus covered are used as warps in a loom, and hemp cord or other fibrous material, previously covered with a solution of caoutchouc or any of the other before-mentioned materials, or not, is employed to weave the whole together.

The fabric thus produced is passed between rollers, to render it flat and smooth, and before or after so doing, a solution of caoutchouc, gutta-percha or a coat of paint, or any other desired material is applied thereto.

M. J. Haines, of Stroud, England, has taken out a patent—bearing date Feb. 14, 1860—for making driving belts.

"This invention consists in cutting leather or hides into narrow strips of equal width, each strip width representing the thickness of the intended driving belt, and placing the same side by side, breaking joints with the lengths to make the whole of uniform strength, and with the cut edges of the leather coming to the upper and under surfaces of the intended belt, until the desired width is obtained. The whole are fastened together by wire, rivets or screws passing transversely through the strips, and secured on the opposite sides."

"An interesting description of American belting is made chiefly of wool, and the surface of the belt covered with a resinous cement. We saw a small piece that had been in use for 2½ years on a heavy cloth loom in the States."—*Lond. Mech. Mag.*, Mar., 1863.

For description of a peculiar form of driving belt, the invention of W. Clissold, see *Frank. Inst. Jour.*, Aug., 1863, p. 121, or magazine above. It consists of double links of leather or other similar material connected by intermediate links of metal, the whole series running in grooved pulleys, the leather only touching the sides of the grooves, and driving by adhesion in the same manner as ordinary round belts.

(To be continued.)

THE CORNWALL BRIDGE.

THE Bill passed in the State Assembly for the construction of a suspension bridge across the Hudson river, 42 miles above New York city, appears likely to be acted upon, and the designs and calculations for the structure are now almost completed. The total length of the bridge, including approaches, will be 2,499 feet, the length between towers, 1,665 feet; the clear span, 1,600 feet; the height of the towers, 280 feet; distance from platform to water level, 150 feet. One of the towers will be in 30 feet of water, the other will be a land pier. The bridge will be carried by twenty cables, disposed in four systems; each cable will be 14 inches in diameter, formed of steel strands, disposed as in Mr. Roebling's bridge at Cincinnati; these, combined, will require 70,302 miles of steel wire for their manufacture. There will be 58,084 cubic yards of masonry in the towers.

There will be a road platform, as well as a railroad track, which latter is calculated to a working load of 2,400 tons. The platforms of the bridge would be filled by 32 passenger cars, or 53 locomotives, and 18,000 people, whilst the working strength allows for the crowding of 34,560 people and 60 locomotives upon the platforms at one time.

The bridge, which is estimated to cost about 500,000*l*., will connect the mining districts of Pennsylvania with the New England States, and effect a saving of four shillings a ton on the four millions of tons of coal now consumed annually in New England. At present, about a million of tons are carried every year down the Hudson to the depôts along the coast. By means of a short branch made to the bridge, the Erie Railway will be enabled to obtain a station in New York, and be saved the expense and inconvenience of transferring goods and passengers by ferry to their terminal station in Jersey City.

Pending the completion of the bridge, a ferry will be established at the point of crossing, for the transfer of the traffic, as the railway will be completed up to the east and west banks of the Hudson long before the permanent connection can be made.—*Engineering.*

EXTRACTS FROM AN ENGINEER'S NOTE-BOOK.

By W. M. Henderson, Hydraulic Engineer.

By particular request, the following notes, relating to the subject of steam boilers, are offered to those interested in the matter of the late steam boiler inspection law. The information conveyed has been condensed mainly from the works of William Fairbairn, Robert Armstrong, and Charles Wye Williams, interspersed with the results of twenty years practical experience of the writer in the premises.

Chemistry of Combustion.

Ordinary combustion is the combination of oxygen with the combustible element of fuel. In coke and charcoal, carbon is the sole combustible element; while in coal there is hydrogen also. In 100 pounds of good coal, there are about 84 pounds of carbon, and 6 pounds of hydrogen; the residue is composed of matter that does not assist combustion, but sometimes retards it by forming clinkers, and otherwise obstructing the process. The hydrogen furnishes weight for weight, about four times as much heat as the carbon, or 22 per cent. of the whole. The products of combustion are:

Steam.....	H 2, O 1	in weight as	1 to 8,	invisible and incombustible.
Carbonic acid..	C 1, O 2	" "	6 to 16,	" "
Carbonic oxide,	C 1, O 1			invisible and combustible.
Smoke				

The first part of the pr of burning coal, consists in distilling, or expelling by heat, ydrogen, in the gaseous form, combined with the carbon in one or two proportions, forming carburetted hydrogen, or coal gas, H 2 C 1 in weight, as 1 to 3, and bi-carburetted hydrogen or olefiant gas, H 2 C 2 in weight, as 1 to 6, the latter forming 10 per cent. of the whole. Taking this estimate, we find that nine-tenths of the six pounds of hydrogen combines with three times its weight of carbon, taking up 16·2 pounds of the latter, and one-tenth combines with six times its weight, taking 3·6 pounds, together taking 19·8 pounds from the 84 pounds of carbon in the 100 pounds of coal, making 25·8 pounds of carburetted gases, to be burned above the coke, leaving 64·2 pounds of carbon to be burned in the form of coke.

Now to burn one pound of hydrogen requires eight pounds of

oxygen, and the product is nine pounds of aqueous vapor; and to burn one pound of carbon, requires two and two-third pounds of oxygen; the product being three and two-third pounds of carbonic acid (the resultant of perfect combustion). Hence to burn the six pounds of hydrogen requires 48 pounds of oxygen; and to burn the 19·8 pounds of carbon, combined with it, requires 52·8 pounds; altogether 100·8 pounds of oxygen to burn the gaseous portion of 100 pounds of coal. To burn the 64·2 pounds of carbon that remains upon the grate, after the expulsion of the volatile gases, would require 172·2 pounds of oxygen, the sum of both being 272 pounds of oxygen to consume 100 pounds of coal.

Atmospheric air consists of volumes N 4 O 1 in weight as 28 to 8; the oxygen being but one-fifth of its bulk, and the quantity required being as 2 to 1 of the carbon, in order to produce perfect combustion; the quantity of air employed will therefore be ten times the volume of the gas to be consumed. From this it will be seen that 1,224 pounds or 16,320 cubic feet of air must be admitted to effect the combustion of 100 pounds of coal, allowing that 60 cubic feet of atmospheric air are required to produce each pound of oxygen. The quantity chemically required for one pound of coal is therefore about 164 cubic feet, of which 60·8 enters into combustion with the volatile gases, and 103·2 with the solid portion of the coal. At the general temperature of the furnace, 1,000°, these products of combustion expand about three times the original bulk of the air, *i. e.* $164 \times 3 = 492$ cubic feet of air and gas to be passed with a velocity of 36 feet per second.

The formation of carbonic oxide is known to be greater in a thick fire with a poor draft, than in a thin fire with a strong draft; in the former case, there may be perfect combustion, producing carbonic acid in the lower part, and the acid so produced may take up another equivalent of carbon in the upper part of the fire; and thus waste half of the carbon, which passes off in the form of carbonic oxide. The remedy for this is a judicious introduction of air above the fire. But to effect the combustion of either gas or solid carbon, it is necessary that the oxygen which is to combine with it, should be brought within the sphere of its attraction; the two must be brought into intimate contact and touch, or nearly touch, while the temperature is favorable. The gas from a burner or candle will not attract oxygen at one-eighth of an inch distance; practically, they must be intimately mixed, before they can burn.

If these conditions be not fulfilled, the combustion will be incomplete; the hydrogen, possessing the strongest affinity for oxygen, will first combine and leave the carbon free, in the form of black powder, which will mix with the vapor resulting from the combustion of the hydrogen, and with the nitrogen gas, and constitute what is called smoke. Now, if this smoke, containing, as it often does, valuable quantities of uncombined carbon, comes in contact with cold surfaces, it loses heat, falls to the temperature of steam, and its combustion is then practically impossible.

At the moment the hydrogen and oxygen combine to form water, they are at a white heat; if, at this moment, there be present a sufficient excess of oxygen, the carbon will be consumed; but if at this moment, the carbon is not also combined, smoke ensues. The problem is to burn the gas in the act of distillation at one operation.

Philadelphia, February 6, 1869.

(To be Continued.)

BRIDGE AT OMAHA, (U. S.)

One of the most important works on the Union Pacific Railroad —the construction of a bridge across the Missouri river, at Omaha, 400 miles west of Chicago—is about to be commenced by General G. M. Dodge, engineer of the Union Pacific Railway. The bridge is about 2,800 feet long, and is divided into eleven spans of 250 feet each, the piers being cylinders of cast iron, 8 feet 6 inches in diameter, and filled with concrete. The treacherous bottom of the Missouri river presents more than ordinary difficulties in obtaining a reliable foundation, from the great depth of the shifting sand, which is constantly filling up old channels and opening fresh ones, so that the section of the bed is ever varying. Where it is possible, the cylinders will be lowered on to the rock, and elsewhere to a depth of 70 feet below low water, in the sand, the bases being enlarged from 8 feet 6 inches to 12 feet in diameter, to spread the bearing surface, which will also be increased by flat bars projecting from the foot of the cylinder into the surrounding sand. Foundations of this class have been successfully employed by the Hon. W. J. McAlpine, in various bridges he has constructed. The length of the cylinders from low water to the underside of the girders will be 69 feet, making a total height of the main columns of 139 feet.

The ten piers, each with two cylinders, will be braced traversely, and protected up stream with ice breakers attached to columns 5 feet diameter, and placed 20 feet in advance of the piers. The faces will be of cast iron plates, meeting at an angle of 45 degrees, in front of the columns, to which they are braced with oak timber, the intermediate spaces being filled with rubble and concrete. From below low water to the highest flood levels, the cylinders will be cased by plates, and the enclosed space will be filled in with concrete, to prevent any accumulation of ice, or other obstructions which may be carried down the stream, from getting between the cylinders, and straining them on the intermediate bracing.

The girders of the superstructure will be trusses made of wrought iron, with the exception of a cast upper chord.

The approaches to the bridge on both shores will be on a gradient of 1 in 30, made in embankment on the eastern side to a height of 40 feet above the ground, the remainder being a viaduct of trestle work. The total length of the whole, including the river crossing, will be about 3½ miles.

Four railway companies are subscribing the funds for this bridge —the Union Pacific, the Chicago and North-Western, the Chicago and Burlington, and the Chicago and Rock Island Railroads.—*E.*

AMERICAN RAILS.

Mr. C. P. Sandberg, whose paper "On the Manufacture and Wear of Rails" just published in this *Journal*, excited such a prolonged discussion at the Institution of Civil Engineers last session, has addressed a letter to the *Times* condemning the system of ordering rails followed by the American railways. Our space will not permit us to publish Mr. Sandberg's letter *in extenso*, but we subjoin an abridgement which will be read with interest. Mr. Sandberg's remarks are very just and well deserving of attention. He says:

"The term 'American rails' has become a synonym for the cheapest and least durable rails manufactured. They are usually about ten shillings per ton cheaper than the ordinary rails made for English and Continental companies. In the case of American rails, the quality of the material and the construction of the rail pile are

left entirely to the manufacturer, the rails not being made according to any specification; and hence there is not the slightest guarantee that a good, serviceable, or safe rail will be obtained; the one great desideratum being, apparently, that the price be low. Hence, the maker's chief study is naturally enough to produce the cheapest possible article, and to devise means of manufacturing at a low price what is, to all appearances, a clean looking rail. To do this, he carefully studies the character of his iron, and so manipulates it as to obtain a well finished and saleable rail, regardless of its brittleness—so long, indeed, as it does not break previously to delivery and payment—and indifferent whether it is likely to last one year or ten. Fortunately for him, the section for American rails is one very easy to roll—low, heavy, and without angles—so that almost any quality of iron and any construction of pile will not interfere with the one object he has in view. When, however, the iron is very red-short, (or liable, through the presence of sulphur, to crack in rolling) a top-slab of a better class of iron (No. 2) must be used in the pile to serve as the wearing surface of the rail. This wearing surface may, however, vary considerably in thickness, forming either the entire head of the rail, or only a portion more or less thick. Even when the iron is not red-short, the pile is often composed of puddled bars only, and rolled out into rails at the lowest possible heat, so as to economize iron and fuel, but regardless of insuring a perfect weld; and hence, lamination and failure rapidly follow after a few months' wear.

"So much for the durability of the ordinary American rail. Now as regards its safety. Just as the presence of sulphur in iron renders the metal red-short, as previously explained, so the presence of phosphorus causes the iron to become brittle and cold-short. It is not, therefore, of great importance in producing a good and serviceable rail from such inferior materials, that the hard, cold-short iron should form the top, or wearing portion of the rail, while the red-short, or tough and fibrous iron, should be used for the flange. As the character of the ores distributed through the principal rail-making districts of this country is such that cold-short iron is produced in one district and red-short in another, it is necessary that the two kinds of metal should be brought together and used in association, as previously described, if they are to produce a truly serviceable rail. But as the cost of transport from one district to another becomes an important item, it will evidently be to the in-

terest of the manufacturer, if not restricted, to use the unmixed home material, whether cold-short or red-short. Under such circumstances a rail is produced either too brittle, and therefore dangerous, or too pliable, and therefore less capable of enduring the wear and tear of traffic. There are, perhaps, few countries that of late have suffered more from fracture of rails than America. This has led some railway administrations in that country to require that the rails should be tested; but whereas they were formerly too careless in this respect, they now seem inclined to err on the other side by specifying too severe a test for the rail, and thus compelling the maker to use too soft an iron. For instance, it is often required that a weight of one ton should fall upon the rail from a height of 10 feet, when half such a test would insure breakage of the rail in any climate. I may now briefly refer to the method adopted in making rails for the English and Continental companies. There are but few of these railway administrations which, when inviting tenders for a supply of rail, do not specify distinctly that the top slab, constituting the wearing surface of the rail, must be of the very best material, and at least 2 inches in thickness, thus giving a wearing surface of ½ inch in the head of the rail; and, further, that the rail should stand a test half as severe as that previously mentioned as applied to American rails. From what has now been advanced respecting the different modes of manufacturing American and European rails, I leave the respective American railway administrations to judge whether they would not best consult their own interests by adopting the English and Continental system of well-defined specification and tests, instead of looking merely to the small saving effected by always accepting the lowest tender."—*E.*

SUBMARINE BLASTING.

THE East river entrance of the New York harbor is obstructed by the presence of sunken rocks, which render the navigation of deep draft vessels a matter of considerable difficulty, and of no little danger. Sixteen years ago the obstructions were partially reduced by blasting, but the process, which consisted of lowering charges of gunpowder upon the rocks, and igniting them by a battery through connecting wires, served only to remove such salient points as presented themselves to the action of the powder.

The improvement of this portion of the harbor has lately again occupied the attention of the United States Government, which has appropriated 17,000*l.* to this object.

Preparations are now being made for the removal of one of the principal obstacles known as Hell Gate, and special apparatus has been designed for drilling the sunken rocks for the introduction of the charge. The principal part of the machine is a water-tight iron casing, in form a depressed semi-spheriod, 7 feet in diameter. It has three solid steel feet or toes by which its stability on the rock is secured. Rising from the upper part of the casing is a conical wrought-iron frame, supporting the upper end of the drill shaft by means of two parallel rods entering into sockets in a cast ring at the top of the frame. The drill bar passing up through the centre of the top is furnished at the bottom with a bit, one and half inches diameter, having imbedded in its face nineteen diamonds, and rotating at the rate of from 300 to 500 revolutions per minute, advancing at the rate of from one to one and half inches in the same time.

The feed is caused by a differential gearing which steadily operates to advance the drill into the rock, the débris being washed away by the water forced into contact with the bit through a small rubber hose. The water-tight chamber of the machine contains a pair of engines working at right angles to each other, with an horizontal stroke. As soon as the hole is completely drilled, and also when the drill shaft is withdrawn from the rock, information of this is given by a magnetic bell which is acted upon by a double wire cord insulated from the water and passing down one of the parallel rods or tubes upon which the crosshead is fixed.

This drill weighs nearly five tons. It will be worked from a wrecking tug with a derrick, by means of steam supplied from the boiler of the tug. To prevent this steam being condensed in its passage through the water to the engine, it is conveyed in a hose surrounded by another, through which the exhausted steam passes.

The rock which is to be drilled in the Hell Gate is that known as the "bastard" granite, and is much softer than either the Quincy or Maine granite, on which the drill has been satisfactorily tested. After a number of holes are drilled over a certain space, a diver will descend and charge them with cartridges of nitro-glycerine, which will be exploded in the usual manner. The fragments will be raised by automatic grapnels.—*Engineering.*

PORTLAND CEMENT.

WITH the enormous stores of the raw material for manufacturing cement, possessed by England, together with the advantageous position she occupies with respect to fuel, it is no wonder, accustomed as we are to be foremost in all matters of a remunerative commercial character, that we have almost a monopoly of this indispensable aid to construction. Mr. Reid has followed in the wake of Mr. Grant, and has added to our very scanty practical information upon the manufacture of Portland cement by the excellent treatise* he has lately given to the public. Without desiring to accuse our engineers and architects of being remiss in their duties, yet it must be acknowledged that the credit is due to our professional brethren on the other side of the water, for directing attention to the admirable qualities possessed by cement for foundations under water and damp and spongy situations. As a rule, the French were long before us in the use of cement, concrete, "pierre perdue," bêton, agglomeré and, in fact, every description of artificial masonry. We for some time refused to abandon stone, and bricks and mortar, and adhered to the ancient types of construction, with true Anglo-Saxon obstinacy and perversity. Gradually, however, we were brought to see the error of our ways, and the commercial element mingling strongly with the adoption of cement, we now not only manufacture it on a very extensive scale, but use it also to a considerable extent, in subaqueous and other works. The application of this important material appears to be almost illimitable even at present, and it promises to embrace a still wider sphere of action. All the engineers, foreign as well as English, concur in commending it highly in whatever works they have availed themselves of its services; and now that it can be obtained of the strength and quality required, there is no longer any doubt remaining regarding its being a thoroughly reliable and trustworthy material.

Mr. Reid enters at full length into the practical manufacture of the article, and describes in detail the various processes it has to pass through before its raw constituents, the chalk and the clay,

* "A Practical Treatise on the Manufacture of Portland Cement." By HENRY REID, C.E. To which is added a Translation of M. A. LIPOWITZ's Work, describing a New Method Adopted in Germany, of Manufacturing that Cement. By W. F. REID. London: E. and F. N. Spon, 48, Charing-cross, 1868.

can be presented to the public in a marketable form. Washing, mixing, burning and grinding constitute the principal phases of the ordeal it is submitted to, and in the first and second of these, which are really accomplished at the one and the same operation, there exists a difference between the plans adopted by the English and the German manufacturers. The former use the wet and the latter the dry systems. Each of them have certain advantages of their own, and it is perhaps as much a matter of habit and national individuality as of any practical superiority. Our author, on the whole, gives the preference to the wet system, although he fairly admits all the advantages that may be possessed, and are urged in favor of the German method. The necessity for sampling the cement, that is, testing it after the operations of washing and mixing have been carried out, is strongly insisted on as one that should never be omitted, for if the proper proportions in which the chalk, clay and water should be mixed, are not discovered at this juncture, it will be too late to remedy the evil afterwards. Two descriptions of tests, namely, the water and the air or dry test, are employed, and the experienced hand can tell by the united aid of the two, whether the mixture has been properly accomplished, and whether it should be allowed to pass on to the kiln. With respect to this latter part of the machinery employed, it does not appear to have arrived at the condition of comparative perfection it should have done. The original lime-kiln shape has not been much departed from, and the whole operation is conducted in a very rough, unscientific manner. In the appendix—or, rather, the second portion—of the volume, a description is given of an endless kiln, which would supply some of the deficiencies found in those of ordinary construction. Notwithstanding the practice and experience that the author has had in the matter, he confesses that it is quite impossible to calculate the time for burning a kiln, and he mentions an instance that came under his own immediate knowledge, where the difference between the periods of burning the same kiln was as four to one. After noticing the grinding process, and the machinery adopted for effecting that somewhat arduous task, the author proceeds to the question of testing the cement. It is not too much to assert that had it not been for the Metropolitan Board of Works, and the energy and decision with which Mr. Grant carried out the provisions of the main drainage contracts, we should never have been able to procure the cement that can now be had with facility. It was at one

time considered impossible to manufacture it of the strength required, and some firms openly expressed their disbelief in the possibility of the results. But after some quiet discussion on the matter, and finding that the engineers would not yield, they betook themselves seriously to the task, and speedily discovered that they had been making a mountain of a mole hill, and that the difficulty was easily surmounted. The needle test is still used in France, but it is fast becoming altogether obsolete, and has been replaced by the tests referring to the tensile strength of the cement, the relative solidity or resistance to fracture, and the compressive strength or resistance to a force tending to crush it. In Germany, they test Portland cement against equivalent blocks of stone and brick; but this is evidently but comparatively worth little, since no two specimens of either stone or brick possess constant qualities in this respect. With regard to tests for durability, the cement has so lately been manufactured of a really reliable character, that it is premature to indulge in them.

Most of the applications of cement, whether in its pure state, or any one of its numerous combinations, are known to our readers, especially its recent application to the construction of dwellings, warehouses, and other buildings of large size. There has one been made which is not so very generally known. It is the application of the material to prevent oxidization in the holds of iron vessels, and also to the external use of it in coating ships. Captain Cowper Coles, C.B., has applied it in the latter manner upon several vessels, and apparently with much success. Another comparatively novel method of utilizing this valuable material, is in concrete for the construction and repair of the surfaces of roads. Although, partially, this experiment has been successful, it has also failed lamentably in one or two instances. Mr. Reid candidly admits that it proved a failure in St. James' Park, although he gives a ready explanation of the cause of failure, of the reason why the surface broke up under the action of the rapid traffic over that part of the Mall. We do not consider that a second attempt would also necessarily prove a failure; on the contrary, it would probably turn out a success, but until further experiments have been undertaken, and more reliable data supplied, we should be careful of expressing a decided opinion.

The second portion of this valuable treatise is devoted to a translation of the work of M. A. Lipowitz. It is in a more condensed

form than the preceding portion, and it is not by any means of the same value. In fact, it would do the work not the least harm if it were omitted altogether, as a portion of it must, of necessity, be repetition. It treats, principally, of the German methods and class of machinery, and contains some good plans and sections of those employed in that country. Mr. Reid's volume is, in fact, the only book of its kind, and one very much wanted. It is true that the experiments of Mr. Grant cannot be overrated; but they do not supply the practical information afforded in the volume in question, which is a complete guide for the manufacturer, authority for the professional man, and a book of reference to every one who desires to become acquainted with the theoretical and practical history of Portland cement. The plates are very well lithographed, and the type clear and well chosen. It is not often that we have reviewed a book with so much pleasure as at present, and we can cordially recommend it as a capital text-book and manual of the subject upon which it so ably treats.—*Lond. Mech. Mag.*

Railway Management in Egypt.—Mr. McGregor, the well-known owner of the Rob Roy canoe, has been recently making explorations in Egypt and Syria; and in the course of an interesting letter to the *Times* describing his adventures, he speaks as follows as to the management of the Suez and Cairo Railway:—"My Canoe was carried by railway from Suez to Cairo with much difficulty and expense. The natives laughed at me for 'buying tickets' as a passenger, it being the constant practice on that line to bribe the guard with five francs and travel as one likes." We should think that a guard's situation on the above line would be a fine opening for a man not troubled with too sensitive a conscience.

Mechanics, Physics, and Chemistry.

THE BEST MODES OF TESTING THE POWER AND ECONOMY OF THE STEAM ENGINE.

By Charles E. Emery.

Late of the U. S. Navy and U. S. Steam Expansion Experiments.

(Concluded from page 120.)

Having discussed the various measures and means that may be employed for our purpose, we desire next to select such as will be useful in particular cases, and show their practical application—which leads us to

The methods of conducting Experiments.—I. Testing Boilers.

The power of an engine can never exceed that of the boiler which furnishes it with steam; hence, it is eminently proper that we should first select measures to ascertain, in a given instance, whether the steam is economically generated. As has been said, the heat-producing power or evaporative efficiency of a boiler is measured by the number of pounds of water evaporated per pound of coal from a given temperature, say 212 Fahrenheit. We have, therefore, to weigh the water evaporated and the coal producing the evaporation—a very simple thing, apparently, but one about which there is much misapprehension, resulting in statements grossly erroneous and ridiculous. The water may be measured in a tank or barrel, the contents of which has been ascertained, by careful measurement, or by weighing water into it of a given temperature. When experimenting, the water in the tank should be pumped out dry, if possible, or at least to a given mark—the pump then stopped, the tank refilled to the proper height (the easiest way is to overflow it), when the supply can be shut off and the operation repeated. The supply pipe should be arranged so that the water can be seen entering the tank, and leakage detected while the pump is working. The better way is to have a hose, to throw in and out of the measuring tank. Before making an experiment, it should be

ascertained if the boiler foams, or raises water; if so, it must be remedied before proceeding farther. All leaks about the tank, pump, and boiler should be stopped; and all extra pipes leading water in or out of the boiler be disconnected, or frequently examined. The steam generated may be worked off in the engine, blown off through the safety valves, or otherwise disposed of, so long as no water is lifted with it. The latter is less liable to happen when the evaporation takes place under considerable pressure. The greatest care is necessary in commencing and ending experiments. There are several methods of doing this. The first is, to measure the temperature and height of the water in the boiler, and immediately upon starting the fire, to keep an account of the fuel consumed until the close of the experiment, then to weigh the coal and ashes hauled out of the furnace. This involves a calculation to ascertain the heating effect of the fuel used in generating steam. It is of little value for the purpose of comparison, for the shell of the boiler and its surroundings (often a heavy mass of brick work) has also to be heated, and of this no estimate can be formed. Another plan often adopted is to get up steam with wood, and allow it to burn low, leaving only sufficient fire to start the coal. The experiment is started when the first coal is put in the furnace, and terminated when the last coal is nearly burned. This plan is supposed to give an accurate measure of the coal burned. The better plan is, to get everything in average working condition before starting to experiment. The steam should have the proper pressure; the fire be clean, and of a certain thickness, judging by marks on the sides of the furnace; the ash-pits clean, and the water at a certain known height. The experiment may then proceed, weighing all the coal afterwards used, and measuring the water pumped into the boiler, till near the desired time to stop, when the fire should be thoroughly cleaned, and filled up with coal to the same marks as at the beginning, and should be maintained at that point, with the steam at the starting pressure, till after pumping in the last tank of water, when, as soon as the water level reaches the same height as at starting, the experiment may be terminated. The ashes in the pit should then be weighed, as well as those previously collected. The fire should be equally bright, and the steam pressure the same at the beginning and end of the experiment, so that the water level will be disturbed in like manner. At starting and stopping, a certain feed should be kept on, or the water should be

pumped too high, and time noted when, by evaporation, the level falls to the mark. No experiment should be less than eight hours in length, and a trial of forty-eight to seventy-two hours duration can better be depended upon. During the experiment a log should be kept, upon which should be recorded the time, the weight of the coal and ashes, the number of tanks of feed water, and the temperature of each. The temperature of the escaping products of combustion and of the fire room may also be noted, as well as any evident remarks about the kind of coal, and the circumstances of the trial. After the experiment, the following calculations are necessary: First, in an evident manner, ascertain the total amount of coal and ashes; subtract one from the other, which gives the total weight of the combustible. Then find the average temperature of the feed water and the average pressure of steam, and calculate the weight of the whole quantity of water evaporated, making allowance for its temperature.

The next step is to find the quantity of water evaporated from a constant temperature, say 212°. From formula or tables find the total heat of the steam due to its mean total pressure; from this deduct the total heat which the water contained before entering the boiler. The result is the number of units of heat imparted to each pound of water. Divide this by the latent heat of steam at 212°, and multiply the quotient by the total number of pounds of water evaporated at the observed pressure; the result will be the total evaporation from our supposed temperature of 212° and at atmospheric pressure. The latter divided by the total amount of coal burned, or, if desired, by the combustible, gives the final result, in the usual comparative terms, viz: *the number of pounds of water evaporated per pound of coal* (or combustible). The coal may be corrected to a uniform rate of 10 per cent. refuse, as has been before explained.

We have reason to suppose that in many experiments abroad, the ashes were "weighed back," and credited on the coal account: in other words, that what is reported as coal was really only the combustible portion thereof. In purchasing coal, we pay as much for the ashes as for the combustible, and ships must carry both, in a combined state; therefore, the report of every experiment should clearly state what is meant by the word COAL, if that be the term employed, whether the weight of the coal as actually purchased, that of its combustible, or a weight proportioned to the combustible, on our plan of correcting to a standard of 10 per cent. refuse.

II.—Testing Engines.

We will examine, first, a simple mode, which may be practically applied, in any case, to test the economy of steam machinery, in the actual performance of its regular duty. In ordinary trials, when but little care and expense can be afforded, the engine and boilers must be tested as a whole, the comparison being made by the "*number of pounds of coal consumed per indicated horse power per hour.*" The indicator is used to measure the power, because, as has been before explained, it is the simplest device we have for this purpose, and most generally applicable. The results will be of little value, however, except under the conditions hereinbefore expressed. We first desire to give, from our experience, some directions about the use of the indicator and the manner of attaching it to the engine. Since the invention of the "Richards" or "Porter Indicator," the direct-acting instrument known as the "McNaught Indicator," has fallen into disuse, except on engines working very slowly. We will make our remarks more especially applicable, then, to the first instrument, often called the "parallel motion indicator." Before using the instrument, see that it is correctly made and in good order. To do this, examine the piston, see that it moves freely, without shake, through the entire length of the cylinder. See that the spring screws down squarely on the piston, and does not tend to one side, and thus make friction in the guide of the piston rod. Examine every joint, and see that it is free, without shake; see if the two links are parallel at all times, and the radius arms at mid position—if not, the arrangement is not a parallel motion, and must be corrected. See that the arm carrying the levers has no vertical shake; see that the barrel runs true, and adjust a pencil in place to bear lightly upon it. The scale of the indicator should be tested by a mercury gauge, and the mark on the spring corrected accordingly. This is important, for the reputed scale is rarely correct, and during repairs it is often varied. The instrument should never be connected to the cylinder *ports;* nor in any position where a current passes the connecting pipe. The connection should be large, short, and direct. Be careful to give the barrel the correct reduced motion of the engine piston. Other details may be arranged as convenient. The instrument should be thoroughly heated before taking a diagram or marking the atmospheric line. The pencil should be made to bear as lightly as it

will make a mark, and it should be allowed to run over the paper several times. Both ends of the cylinder should be indicated.

Before beginning an experiment, both engine and boiler should be in average working condition. At the commencement the fire should be clean, and its thickness noted. The contents of the ash-pit should then be removed, and the coal be weighed, the same as in testing boilers. Indicator diagrams should be taken once an hour, or every half hour, or even less, if the load varies considerably. The pencil should be allowed to remain on each diagram a considerable time, to get a fair average. A register or counter should be attached to the engine, the indications of which should be noted at the beginning and end of the experiment, and every even hour intervening. If a register cannot be obtained, the revolutions should be counted and recorded every fifteen minutes. This should be continued not less than eight hours, and a longer time is preferable. At the end of the experiment the fire should be clean, and of the same thickness as at the beginning, the same as in testing boilers. A log should be kept during the progress of the experiment, showing the time, pressure of steam, revolutions of engine, weight of coal and ashes, and other matters of interest. The calculations are simple, and need not be detailed. We will here remark that the fault with most experiments is the short time for which they are tested. To ascertain accurately the consumption of fuel in a given case, requires, as has been said, at least eight hours continuous action, and the mean power cannot be obtained, in many instances, in much less time. A single diagram, taken occasionally, gives little idea of the actual power exerted, for in every manufactory the load is constantly changing. It is more than probable that the excellent results claimed in many cases are obtained by calculating the power from a diagram taken with the full load on, and the cost of the power from the average coal, or worse yet, from the coal which is thrown in the furnace in any particular hour, without noting whether the fire is heavier at the beginning of the hour than at the end. A manufacturer's coal bills always tell him what his steam power has cost for a given time, but his one hundred horse power engine might have been exerting, on the average, only fifty horse power; so, without actual and careful observation, no results can be obtained of any value to the engineering profession. The only true way is to make thorough trials, and repeat them until the results practically coincide.

When the power of the engine is measured by a dynamometer, the same care should be taken to frequently record the revolutions of the engine and the indications of the instrument, so as to be able to calculate the true average power. Fuller reasons for such precautions have already been given in the preceding discussion.

We are now prepared to select the methods and means necessary for a scientific trial of the economy of steam machinery, which shall be complete, and above criticism. We must first bear in mind that it is the *economy* that we wish to test, and not the excellent manner in which some device controls the speed of the engine, under varying loads. Special trials may be made of each detail, if desired, but only one thing can be tested at a time. To get accurate results, great uniformity is necessary. The closer the resemblance between the records, at different times, the more correct will be the averages. It is essential, then, to carry a uniform pressure of steam, and to have a uniform load and speed to the engine. In regular practice the load is necessarily varied somewhat, which can only be provided against by frequent observations; but our remarks are more particularly applicable to an establishment fitted up especially to test steam machinery, and in other trials details must be varied according to circumstances. In such case the boiler should be of ample size to do the work, and the pressure should be regulated by a steam damper. The resistance should consist of wind or water wheels, or pumps. We prefer high speed fans or blowers, as the resistance can then be easily regulated by varying the size of the discharge openings. Tanks should be provided for measuring the feed water of the boiler, and it would be well, though not strictly necessary, to have a surface condenser from which to collect and measure the distilled water, and thus, in two ways, ascertain the quantity of steam used. The power of the engine should be measured both by the indicator and dynamometer, and duplicate registers should be provided to count the revolutions. The better plan, in order to give the same area of indicator diagram, is to use, in each experiment, a cut-off, fixed at any desired point, and *not* use the governor. In such case, special means must be provided to keep up a uniform lubrication, which, with the uniform resistance proposed, will secure uniform speed.

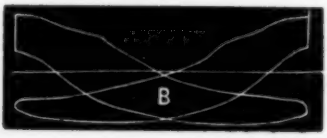
When experimenting, the coal should be weighed, and the feed

water measured, or weighed, with all the accuracy required for testing boilers. At the same time, indicator diagrams should be taken at least once an hour, and the reading of the dynamometer recorded. A record should also be kept of the time, revolutions of engine, steam pressure, and the temperature of the feed water, and in a condensing engine, of the hot well and circulating or condensing water. The temperature of the engine and fire room, and of the external air, should also be noted, to show the effect on condensation in the pipes and passages. The direction and force of the wind is also useful, to show its influence on the fires. Barometrical observations are essential, to show the true zero of the steam pressures. Experiments conducted thus carefully, and with such apparatus, would furnish results of the greatest value to science. Each trial would show the economy of the boiler and of the engine, also the friction of the engine and its load, and the net power and its cost; besides affording much valuable information to aid in the explanation of the losses which now exist in the steam engine, and suggesting improvements in its construction. The United States Expansion Experiments were tried, substantially, on this plan, but were stopped when results were being obtained of the greatest interest. Could an experimental establishment be now opened to manufacturers and inventors, how much capital, physical exertion, and mental anxiety could be saved, and how greatly the steam-engine might be improved. Without such a place, however, much good can be done, if every engineer will carefully use the means at his command, and record the results. The awards at all our Fairs should be based upon trial, and not upon mere opinion.

The "Yankees" are an ingenious people. Let all assist in directing this ingenuity into scientific channels, and the character of the result may be judged from the present advanced position of our high-pressure engines. By fully discussing the subject of economy, and generally circulating complete records of competitive trials, an important branch of industry will be stimulated, all classes benefitted, and American Engineering become the standard throughout the civilized world.

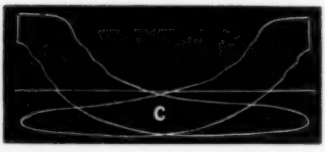
NOTE.—The following diagrams were selected from a number taken by the writer to test the accuracy of the steam engine indicator, under the circumstances mentioned on page 51. The pres-

sure of steam in the boiler, and the speed and load of the engine, were the same in all cases. The only conditions changed were first, the point of cut-off, by shifting the link, and second, the amount of throttling which was adjusted to make the speed equal in all cases. An indicator of the "parallel motion" variety in excellent condition, was used in all the experiments. The scale of the instrument was sixteen pounds to the inch, and the speed of the engine during these trials was fifty-one revolutions per minute. Under such conditions, when the actual power exerted was of course the same in all cases, the indicator showed the following:



Mean pressure Diagram A, 8·6 pounds, Relative indicated power, 100
" " " B, 9·45 " " " " 109·9
" " " C, 11·06 " " " " 128·6

These remarkable discrepancies can be attributed to nothing but the indicator itself. The experiments were several times repeated, and every precaution was taken to get accurate results. Confirmatory experiments were tried also under different conditions. The discrepancies above shown are greater than would ordinarily be the case, these diagrams being selected because the differences can be detected by the eye without measurement. The increase shown at the shorter points of cut-off is due as has been said to the inertia and friction of the moving parts of the instrument, but chiefly, we suppose, to the latter, as the variation caused by the first nearly corrects itself in vibrations. Had the mean pressure been greater, the discrepancies from using the same instrument would have been but little more, and would therefore have been of less relative value. Again, the cushioning, shown in the diagram, undoubtedly causes double the amount of discrepancy which would be found in an engine making the same steam line, but having a more uniform exhaust pressure due to independent valves.



P. O. Box 2161, New York City.

ON THE IMPORTANCE OF AQUEOUS VAPOR IN WARMING AND VENTILATING DWELLING-HOUSES.

By Charles M. Wetherill, Ph. D. M. D.

Professor of Chemistry in the Lehigh University.

The importance of the vapor of water in the atmosphere of our dwellings during the winter season, is not denied by any one; but the proper means for securing this condition is neglected, even by those who acknowledge its importance, and in the various appliances for hydration in the construction of hot air furnaces the means adopted are entirely inadequate.

The writer has had his attention forcibly directed to this subject by a series of experiments and analyses made in Washington, in 1866, upon warming and ventilating the Capitol (House of Reps., 39th Congress, 1st Session, Ex. Doc. No. 100), and now again in his own dwelling, and also in the new university building, Packer Hall, which is warmed by an abnormally dry air, made so by passing over steam coils, as in the capitol.

He has thought that a few remarks would not be out of place in this connection, and he would feel amply repaid if any of our practical men, profiting by the suggestions, would supply the deficiencies complained of, and advance their fortunes by the invention of a hot air furnace constructed upon scientific principles.

This problem has never been solved practically, and yet it admits of a solution.

A great difficulty meets us in the outset, viz: an inertia to be overcome in the public mind, as well as in the opinions of practical men, with respect to the requisites of a more perfect system of warming and ventilation. Thus a class of inventors direct their attention to the construction of the stove to ensure economy of fuel and rapidity of warming the air, and another class discuss the merits of a downward or upward ventilation, while all (even those who admit the necessity of it), neglect the consideration of the best means of effecting the hydration of the air, at least in dwelling-houses, and of the actual amount of water necessary for the purpose.

As a result of the experiments at Washington, after much money had been spent for the investigation, and after it had been proved conclusively by the experiments that the warmth and ventilation

were abundant (even excessive), and that the sole cause of discomfort arose from too low a relative humidity in the air, Congress could or would only appoint a fresh committee to inquire into the means of procuring a more efficient *ventilation* for the Capitol!

In the furnaces which admit the necessity of water, a small panful is afforded, without any further consideration of its efficiency, when the dried up feelings and warped furniture of the inmates of the house are protesting constantly as to its inadequacy.

We use the term "*relative humidity*," to designate the percentage of water which air of a given temperature holds in solution as vapor. Thus, when air of any given temperature contains all of the moisture, which it is able to hold as vapor, we say its relative humidity is 100; if it contains half as much, its relative humidity is 50; relative humidity 10, indicates that the air has 10 per cent. of the vapor of water, which it is able to hold *at that temperature*.

It is a property of air that the quantity of water which it may dissolve to saturation, *increases with the temperature* of the air. Hence, air which is saturated with water at 70° (*i. e.* has a relative humidity of 100), may still have a relative humidity of 100° (*i.e.* be still saturated with water), when cooled down to 32° but does not contain so many grains of water per cubic foot as it did, a portion having been precipitated or condensed as drops of water by the effect of the cooling. Conversely, air having a relative humidity at 32° of 100, has its relative humidity reduced to 50 by being raised to a temperature of about 50° Fah.; or to 25, if it be heated to about 72°.

When the air is moist, we say that it has a high relative humidity; and when its relative humidity is *low*, we say that the air is dry.

What is the effect of these two conditions upon the human body? When the air is saturated with moisture the evaporation from the skin and lungs is arrested, and those interior movements of the bodily fluids necessary to health are restricted. The body is in the condition obtained by the Russian bath, but without its elevated temperature; is in an unnatural condition. The amount of animal heat removed by the evaporation of the corporeal moisture is no longer withdrawn. Even the beneficial effects of the Russian bath are wanting, for the shock to the nervous system is absent.

When the body is in air of too low a relative humidity, the opposite conditions are present. An abnormally large amount of heat is abstracted by the evaporation; the motion of the corporeal fluids

is excessive; the necessary moisture is removed from the lungs and skin, we feel parched and dry; fevers and susceptibility to cold, together with other human ills, are manifested.

Who has not noticed the great access of disease and of lesser bodily disturbance which a dry heated term of our summers is sure to bring? These evils may all be observed in our furnace heated winter dwellings, and are making their impression particularly upon the rising generation of our cities. Dr. John Bell has said that we, "of the middle states, are nearly in the situation of those who should spend their summer in Egypt and their winter in Russia." Desor attributes the restless nervousness of Americans to the dryness of our climate.

We can overcome these difficulties, at least in the winter, by attending to the relative humidity of our dwellings, and we may constantly test their degree of humidity by the simple hygrometer of Edson or of Mason.

The problem to be solved falls into two parts:—

1st. What is the relative humidity for an agreeable temperature most conducive to health?

2. How may we maintain that humidity by a hot air furnace.

If we determine the amount of moisture needed in the air for health, we can ascertain very readily the quantity of water in the cold air, and consequently how much we must add to it to give it when warmed, the healthful relative humidity. It will be the duty then of the furnace (supported by a proper construction of the building for ventilation), to give this water.

The problem is a very difficult one for large halls filled with an audience, but for private dwellings is much simpler.

1. Experiments upon the first head are wanting.

We will not go astray, though, if we assume that the Creator has placed us to live in an external atmosphere of the proper relative humidity, and that since he has given us, through our reason, the power to combat the cold of winter, we may use the same faculty to draw proper conclusions as to atmospheric moisture.

The relative humidity of the external air varies from 100 to 12, and lower. It is greater in winter than in summer, although in winter there is less water in the air on account of the cold having condensed the moisture. The mean relative humidity of the year will give us that quality of air best suited to our nature, and that which we must imitate in our plans for artificial warming and ventilation.

The mean relative humidity of Washington for the years 1856–58–59, was 68·15.

That for Philadelphia from twelve years observation was 68·5. Müller gives the annual mean relative humidity of Halle, Germany, at 75. Roscoe states that the experience of heating and ventilating the House of Lords, demonstrated the most agreeable relative humidity to be not less than 55, nor more than 82, of which the mean is 68·5. My own observations of the air of the Mammoth Cave of Kentucky, showed a relative humidity of 87·6 and a temperature of 58°; an agreeable temperature and humidity for exercise.

These considerations lead us to adopt for the relative humidity of our winter dwellings the standard which nature furnishes us; it should range between 50 and 75, of which the mean is 67·5. It should be, as I have given it, slightly lower than the annual mean, since the relative humidity is a little higher in winter than in summer. The proper degree of humidity in our warmed rooms renders a lower temperature agreeable; the moisture in the air acts like a blanket to retain the heat of the body.

2. In order to maintain the relative humidity of the air of apartments at a given point, say only 50 for a temperature of 70° Fah., the temperature of the external atmosphere being at 32° Fah., and nearly saturated with moisture, we have to make calculations which will give varied results, according to the construction of the house. We must consider how much warm air per minute enters it from the furnace, and how much from the external atmosphere by the windows and doors, the sum of these leave it per minute, and constitute the ventilation. Also what are the number of its inmates, and how many lights are burned; although this is of minor importance in private dwellings, where the ventilation is generally in excess.

In a sleeping room in Washington, heated by a fire in an anthracite grate, and occupied by two adults and two children, the relative humidity in the morning before any doors were opened, was 46, the temperature of the room being 68·4 Fah. The carbonic acid was only double that existing in the external air, demonstrating a very efficient ventilation effected by the chimney.

The following calculations must be regarded as giving only general results to direct attention to the subject, and to form a basis upon which to experiment for the attainment of a more perfect furnace.

A cubic foot of air at 32° Fah., when saturated contains 2·126

grains of water. Let us suppose that it is nearly saturated, and contains 2 grains. If it be raised in temperature to 70°, its capacity for moisture is raised to nearly 8 grains, and as no water has been added, it is no longer nearly saturated, but is *very dry*. Let us see how much water it contains. Air expands $\frac{1}{492}$ of its volume for every degree above 32° Fah.; 492 cubic feet at 32° would become 530 cubic feet at 70°; hence, 1 would become 1·077 cubic feet. These would contain the two grains of water; hence 1 cubic foot would contain only 1·85 grains of water; *its relative humidity has been reduced by the warming from nearly* 100 *to* 23·11.

If we take the minimum relative humidity (viz. 50), that can be afforded for health, this cubic foot of air should contain 4 grains instead of 1·85 of water; there is therefore a deficiency of 2·15 grains for every cubic foot of air of the apartment. In a room of $15 \times 20 \times 12$ feet, containing 3,600 cubic feet, this deficiency would equal 7,740 grains of water, or more than a pint (which equals 7291·11 grains), and in a house of eight times the capacity of the above room, the deficiency would be 61,920 grains, or a gallon plus half a pint.

Every time the air of the house is renewed, a gallon of water must be added to give its *minimum* relative humidity of 50.

The inmates of a room add water to it from their skin and lungs which, according to Hood, amounts to 12 grains per minute, and according to Seguin 18 grains. But carbonic acid is also added, and this must be removed by the ventilation. Hood estimates the ventilation for one inmate at $\frac{1}{4}$ cubic foot per minute for the carbonic acid, and $3\frac{1}{2}$ for the bodily moisture, say about 4 cubic feet per minute. If these 4 cubic feet per minute were not removed, in every hour, only 720 grains of water would have been added to the air from the person of the inmate of the room, leaving still 7,020 of water to be supplied to maintain the relative humidity at 50.

The non-removal of the products of respiration for one person in a room of 3,600 cubic feet capacity for an hour, upon the supposition that such person exhales 0·7 cubic feet of carbonic acid in that time, would give to the air 6 volumes per 10,000 of that deleterious gas; or two volumes more than the quantity naturally present in the air, which is four volumes. It would require $10\frac{3}{4}$ persons to give to the above room by the evolution of their bodily moisture the proper degree of relative humidity, and they would bring the proportion of carbonic acid up to 21·5 volumes per 10,000

(upon the supposition of no ventilation), a quantity entirely too high for health. It follows from this, that it would be impossible to rely upon the respiration and perspiration as a means of supplying a healthful moisture to the air, to say nothing of the disgusting fact of breathing again air thus vitiated.

The absolute amount of water to be supplied.

If we knew how often the air of a house, of the capacity cited, were changed we could easily calculate the water necessary to be added to maintain a relative humidity of 50.

Thus, if in our example it were changed every hour, a gallon and a pint of water must be added to it every hour.

If all of the fresh air came to the room through the register of the furnace, the problem would be less complex, for the proper amount of moisture could then be added at once in the hot air chamber; but a large portion of the air comes from the external atmosphere proceeding from the opening of doors, or drawn into the room through the cracks of the doors and windows. If there be a system of ventilating flues, the renewal of air may be regulated to a certain extent, but if there be open fire-places or fires burning in grates, the ventilation is frequently excessive, and more water of hydration is required per hour. In either case, a large portion of its fresh air enters the room by the cracks of the doors and windows. This obliges the furnace air to be hydrated to a *greater extent*, in order to maintain a relative humidity of 50 in the room. We must avoid the mishap of having such an excess of water that it is deposited in the liquid condition, especially when the heat is turned off from a larger to a smaller number of registers. Hence, to be perfect, an apparatus for hydration should admit of regulation. With respect to the rate of the renewal of the air, it has been found necessary in the halls of Congress to change it every eight minutes, *i. e.* seven and a half times each hour. This rate would not be required for an ordinary dwelling-house, nor could it be effected without powerful means; it would need the evaporation of nearly eight gallons of water per hour.

General Morin performed a series of experiments upon the ventilating effects of chimneys, and the crevices of windows and doors, upon an office in the Conservatoire des Arts et Metiers. (Expériences sur les effects de ventilation produits par les cheminées d'appartment Comptes Rendus LVI. p. 16, 1863.) The room could

be heated at will by an open fire, or by the register of a hot air furnace. He found that the chimney without fire ventilated the room abundantly. He measured the air entering the room, and that evacuated, by determining its velocity by means of a delicate wind wheel, and found that when the external air had a temperature between 35° and 50° Fah., and the interior temperature ranged from 64° to 71°, the chimney withdrew from the room, every minute, 235 cubic feet of air (more correctly 235½), of which 90·30 entered from the hot air furnace and 144·77 through the crevices of the windows and doors. Or about three-fifths of the air entered by the crevices and was warmed by the remaining two-fifths of air furnished by the furnace. The quantity of fresh air thus added every minute, would be contained in a cube, whose edge is a little more than six feet.

Applying these data to our hypothetical house, the air would be renewed every *quarter of an hour*, and would require four gallons and two pints of water to be furnished to the house every hour. Such ventilation is excessive; one-half, perhaps even one-quarter would probably be sufficient for an ordinary dwelling, which would require the addition of two gallons of water (or of one gallon), per hour. It would depend upon the ratio existing between the fresh air furnished by the registers, and that admitted to the house through the crevices, how much of this water could be added by evaporation in the hot air chamber of the furnace.

It is apparent from these considerations, that the hot air of the furnace must contain water almost to saturation in order to effect a healthful humidity, and that the small pan of water in furnaces is entirely inadequate to the purpose. The following experiment was performed in the investigation of the ventilation of the Capitol. An iron tank, containing sixty square feet of water surface, and warmed to 172° Fah. by steam pipes, was placed in the main hot air duct of the House of Representatives. A volume of hot air of the capacity of the House of Representatives passed over this tank every eight minutes, causing the evaporation of not quite fifteen gallons of water per hour; the increase of moisture in the air due to the tank was not more than half a grain per cubic foot of air. With a less active ventilation, the amount of water per cubic foot would have been somewhat greater; but it follows from the experiment that the rapid passage of air over a heated surface of water is not sufficient for its hydration. It is necessary to furnish the water more rapidly as by boiling it; I should have liked to have kept the water in this tank in a state of rapid ebullition.

Suggestions for an improved furnace.

Fig. 1.

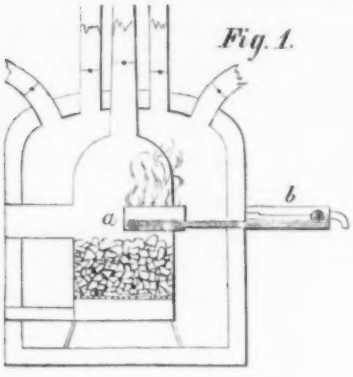
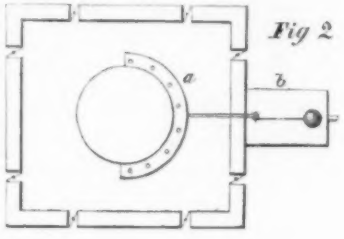


Fig 2



The following suggestions are offered to practical men for an improvement in furnaces.

1. Cease improvements of the stove, making it more complicated and expensive and saving both coal and the trouble of charging it, until a good water supply capable of being regulated is obtained. This would not prevent the supply of moisture to any such complex furnaces if they be preferred.

2. Save the coal, as is done, by dampers in the fire flue and register, in the ash-pit and stove-door. Also by attention to the quantity of air passing through the hot air chamber governing it by dampers in the hot air ducts near the stove, and in the cold air ducts; paying also great attention to the air leaving the apartments, and regulating it as much as possible.

3. Seek some method of adding steam by the action of the fire, and in regulated quantities under control, to the hot air chamber. Perhaps the water tromp for obtaining a blast by the fall of water or the atomizer may be made available. Perhaps some means for the evaporation or atomization of water in the apartment may render assistance in maintaining the proper relative humidity.

The admission of steam to the hot air chamber does not rest upon theory only; it has been carried out in practice by Professor Henry at his dwelling in the Smithsonian Institution. "An iron tube connected with the water vessel in the hot air chamber, was inserted through the side of the furnace into the midst of the burning fuel;" this device kept the water in the vessel in a state of rapid ebullition, raised the relative humidity of his apartments, and a quality

of "softness and salubrity were imparted not before perceived" in the air.

4. The above sketch is suggested, in which Fig. 1 represents a vertical, and Fig. 2, a horizontal section of a furnace improved for hydration. The supply tank, with ball cock, may be placed inside of the air chamber, providing for an overflow through the wall. The water back should not be in the fuel, and devices should be present to prevent unpleasant results from derangement of the water apparatus.

The water must *boil* at the rate of a gallon, or more, per hour according to the ventilation, for a moderate dwelling.

THE NATIONAL WATCH COMPANY.

By Prof. S. W. Robinson, C. E.

On passing through the pleasant little city of Elgin, Illinois, a few weeks since, I ventured to sacrifice a few hours of time at that part of my journey, with a view to visiting the *National Watch Company's Works*, located at that place, to catch a glimpse, if possible, of those wonderful machines that turn out the tiny wheels, which, by their undeviating movements in their allotted spheres, measure off so truthfully the few fleeting moments of human existence. The buildings were reached by about half a mile's walk from the depot. They were originally located at some distance from other buildings and streets, to avoid dust and confusion, but the hundreds of operatives who have come to populate the working rooms of the establishment, and furnish brains to the machines, are building up houses in the vicinity, so that the isolation of the buildings is not so complete as formerly. They consist of a main part, about 40 feet square and three stories high, with which are connected three wings; those toward the east and west being 100 by 28 feet, and two stories high. The south wing, 87 by 28 feet, has one secondary wing, 25 by 35 feet, extending eastward, and the engine room, 30 by 65 feet, on the west side. All are substantial structures, consisting of brick and stone. On entering the janitor's room, and furnishing to one of the proprietors, called for the purpose, sufficient assurance of unobjectionable motives, ready access was granted to the various rooms and departments.

The machine shop of the factory is situated in the lower story of the west wing. The other rooms of the buildings, excepting the east wing, are crammed with the watch-producing machines. About three hundred persons are here at present employed, producing about fifty watches per day. This falls so far short of supplying the great and rapidly increasing demand, that the east wing, lately finished, is being rapidly fitted up with machinery, and the works extended into it. By this addition to the present facilities of the Company, it is expected that, within two or three months, their producing capacity will be increased to nearly one hundred watches per day. This large and thriving trade is being protected by a sound and vigorous policy. No watches are supplied at the factory to individuals, for any consideration whatever, much less at a figure below that of the dealer. They are only furnished at regular fixed rates, and in a considerable quantity at a time, to those in the trade; so that they can have the satisfaction of retailing them at the very lowest prices for which it is possible to secure them. No cases are now made by the Company. The tradesman can therefore supply himself from whatever source, and with whatever quality he chooses.

The machines used in this establishment were manufactured by the Company in their machine shop, occupying a portion of the west wing. Only a few of these machines are automatic, so that the greater portion of them require, separately, an attendant. They are, therefore, much less complex and expensive. As their management requires light and quick movements, they are, perhaps, better manipulated, as in fact they mostly are, by the delicate fingers of girls, who stand ready, by hundreds, to work them at rather low wages. So long as help is cheap, the temptation to complicate the machines into automatic ones, with the sole object of reducing the number of attendants employed, is not very great. Indeed, many of the machines are so simple that they may almost be regarded as only tools, to serve as undeviating guides to the erring hand, enabling it to "draw the bead" so closely upon the fine steel wire. The machines, therefore, exhibit a measure of ingenuity in being simply the very thing needful to the hand of the operative, enabling him or her, with only a few weeks' or even days' practice, to turn out thousands after thousands of separate pieces, so nearly alike that any one of them will satisfy the test of delicate calipers, by which the different thicknesses of two fine hairs may be deter-

mined with the greatest facility. Instead of adopting such simple aids as these, the trans-atlantic watchmakers must devote a lifetime to the acquirement of accuracy in handicraft, transforming them into human machines, who even then can but produce imperfect work, such as requires to be set up by the old "scribe rule." But here, as in all other great manufactories of this country, any piece will fit in the place of any other similar piece, in any article of its kind ever produced.

Of the watches produced by this Company, there are six different grades now in the market, varying largely in price and considerably in quality. The six grades bear the following trade marks, viz:

1st. B. W. Raymond,
2d. H. Z. Culver,
3d. Culver,
4th. G. M. Wheeler,
5th. Mat. Laflin,
6th. J. T. Ryerson.

The essential difference between the first and last three grades consist chiefly in the former having finer toothed wheels, by which the impulses communicated from the main-spring to the escapement are more uniform and regular. The "B. W. Raymond," which is placed in the front rank, in honor of the president of the company, receives numerous fine strokes of the file and polishing powder, whereby some of the corners that appear under the microscope are removed from the minute parts. Although this contributes to their infinitesimal elegance and beauty, it cannot warrant us in claiming therefor much better performance in the pocket. Partiality is also shown this watch in selecting for it the most perfect pieces from all the three first grades. The second best selections are allotted to the next grade. The remainder is appropriated to the last of the first three grades. Although the last three grades are distinguished from the first by having coarser teeth in their trains of gearing, still the difference is not very great, the ratio numbers being about as 8 to 10. The different qualities are here determined as in the first three grades by the method of selections. But these selections do not give rise to so great a variety in quality as one might suppose. Every piece being turned out with the greatest accuracy attainable by practice with machines, giving results which satisfy the most delicate tests, if even one of the lowest grades is proffered us, we need not, as we are amply assured by competent judges, look further for greater perfection in foreign productions. The only superiority possessed by even the highest priced European pocket-pieces over the American, as now

found in the market, consists in the greater care bestowed upon the adjustment of the escapement to pure isochronism. This correction alone is sufficient to run up the cost of a watch indefinitely. It requires the selection of a hair-spring that will give exactly equal times of vibration, whatever may be the extent of vibratory arc. The detection of such a spring, in any given case, is almost a matter of pure chance, and can only be effected by patient and repeated trials. A timepiece thus adjusted is also a most delicate instrument, and should be handled with the most profound respect for its refined virtues, lest at any time they should suddenly depart. Any binding or straining of the spring, while in the hand of a bungler, would greatly jeopardize their safety. The first and chief condition of isochronous vibration is, that the tension of the spring shall increase uniformly with the arc of vibration from the point of repose. As any good spring will very nearly fulfil this condition, and as the immediate object of our American companies is to supply a good substantial article at a low figure, already performing with almost wonderful accuracy without introducing that effeminate principle of unwarranted permanency, which would easily increase the cost from $50, the price of the "B. W. Raymond," to from $100 to $200, without adding a single particle, should we express much surprise that this delicate adjustment should be reserved for the higher priced watches and chronometers?

The escapement introduced into the "National Watch" is of the lever stamp, although called the "straight line escapement." The pallets are "exposed," and situated in a line nearly perpendicular to the lever, which together resemble an anchor with the shank turned outward. The plain steel balance is not so much used as the expansion balance, the latter being preferred by the Company for reputation's sake, and of course preferred by the purchaser. The expansion balance in the higher priced watches is corrected, by trial, to compensate for heat and cold. The very best materials that can possibly be obtained are used in the manufacture of these watches. The pinions, and other steel parts, are made of the best Stubs steel, well tempered and polished. The jewels are of garnet, ruby, and other precious stones, so hard that they will easily scratch glass, and can only be worked by the use of powdered diamonds.

Among the advantages claimed for this watch over all others are the finer wrought gearing and quicker beat. The number

of teeth in the trains of the "Appleton, Tracy & Co." of the Waltham Company, lies between those of the first three and last three grades of the National Watch Company, but most nearly agrees with those of the "G. M. Wheeler," and the following. The Waltham watch has a quick beat, making 16,200 single vibrations per hour. But all those who ride upon railway trains, where the watch is subject to sudden jerks and jars, will at once recognize the advantage of increasing this number to 18,000 per hour, as is actually done in the "National Watch." Although the Waltham watch has, and still is enjoying a high reputation, and has gone into most successful competition with those of European make, yet may we not now unmistakably adopt the concurrent testimony of those who have tried the different timers, and then agreeably look to the Northwest for our real *National Watch*, and feel more than ever the truthfulness of the poetic conception, "Westward the star of empire takes its way."

University of Michigan.

ANALYSIS OF A NEW PIGMENT.

By Chas. P. Williams.

(Late Professor Analytical Chemistry, Polytechnic College.)

The material from which this pigment—now largely sold in New York—is manufactured, is the mixture of zinc blende and galena from the washing buddles of the Silver Hill Mine, Davidson County, N. C. The activity of this mine (since the commencement of mining operations in 1838, under the name of the Washington Mine) has been somewhat intermittent, but when in operation the main object of its exploitation has been the silver and gold occurring in the galena which is associated in the vein with a large amount of blende, and with some iron and copper pyrites. The process of concentrating the galena for the smelting works by means of the circular buddles has accumulated several thousand tons of blende with a small per centange of galena, which, within the last eighteen months, have been utilized by a preliminary roasting at the mine, and by a subsequent treatment at Bergen Port, N. J., according to the method ordinarily pursued in this country for the manufacture of "zinc white" or oxide of zinc. The product thus obtained is, chemically speaking, an impure oxide of zinc, containing a considerable amount of sulphate of lead, and somewhat resembles in com-

position the condensed "fume" from lead furnaces in which a galena containing some zinc blende is treated.*

The following are the results of some analyses recently made of an average sample obtained from a barrel of the dry material. No. I. is by myself; No. II. by Dr. G. A. König, in my laboratory:

		I.	II.
Insoluble in water.	Oxide zinc	72·083	71·680
	Oxide iron	trace.	trace.
	Oxide antimony	trace.	trace.
	Sulphate lead	23·968	24·610
	Oxide lead	·274	not estimated.
Soluble in water.	Sulphate zinc	·810	·931
	Chloride zinc	·839	·965
	Chloride iron	·071	not estimated.
	Chloride antimony	trace.	.....
	Chloride cadmium	·256	·191
	Moisture at 212° Fahr	·398	·270
		98·699	98·647

The method produced in these analyses consisted in extracting the samples with *cold water*, and estimating the chlorine, sulphuric acid, etc., in the usual manner. The insoluble residue was then treated with a solution of hyposulphite of soda till the filtrate no longer gave the lead reaction with sulphydric acid. By this the sulphate of lead was dissolved out, and was afterwards precipitated by sulphydric acid gas, the resulting sulphide of lead being reconverted into sulphate of lead, and weighed as such. The residue was dissolved in nitric acid and was found to contain a small amount of oxide of lead, the oxide of zinc, and traces of oxide of antimony and oxide of iron.

This plan, though somewhat tedious, was followed to avoid as far as possible, all theoretical considerations in reference to the conditions of combination in which the various substances existed in the material.

* Compare Kerl's "Handbuch der Huttenkunde," Vol. II., and Watt's "Dict. Chemistry," Vol. III., p. 526, for composition of "lead smoke" from various processes.

Philadelphia, March 2d, 1869.

EDUCATIONAL

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867-68.

LECTURE III.

(Continued from page 138).

HEAT is the subject for consideration this evening. Fresh air is the greatest of blessings, and to supply it, ventilation is, as we have shown, of the first importance; yet we are much more sensitive to heat and cold than to *pure* or *foul* air.

Heat we have to furnish, in a great measure, ourselves: pure air is supplied us by the Creator. Heat is the prime moving power of the air: it is also the great controlling power of ventilation. It is the *improper cold draughts* that make ventilation so unpopular.

Heat, therefore, is the key that unlocks the door for the free flow of pure air, *i. e.*, for good ventilation. Hence, if we desire such ventilation, we must secure the key that unlocks the door where the treasure is kept. And now let us be sure to secure the *right* key.

There are three distinct methods of heating:

1st. *Radiation*—in which the pure, independent streams, called rays of heat, come directly from the sun or other hot bodies.

2d. *Conduction*—or the means of conveying heat through solids, when the particles of the heat are handed from atom to atom. And

3d. *Convection*—which is the condition wherein certain moving bodies, such as air, water, or other fluids and gases, gather up an armful of heat, as it were, and carry it away in their arms to other parts.

Now, it is necessary that we fully and clearly comprehend these three different ways of communicating heat. It will require a little close attention, but the understanding of it is not difficult, and then

the whole subject of heating and ventilation, which may now appear as a mystery, will soon begin to look quite plain and simple.

For the purpose of classifying the different kinds of heat more distinctly in our minds, let us term them according to their relative value, as follows:

Radiant or *Golden* heat;

Conducted or *Silver* heat; and

Convected or *Copper* heat.

This is about the relative value I put upon these different ways of communicating warmth, for our practical purposes. Now let us consider these three several ways of heating, a little more in detail, taking first radiant heat, or our "gold heat," as that is much the most valuable.

There is a tendency to a perfect equalization of that sensation we call heat, in all bodies. If you should bring a block of ice into this room, and a red hot cannon ball, in a little while they would both have become of the same temperature as the room; the ice may have changed form and turned into water, but (no matter for that now,) they would both have become, as I said before, precisely of the one temperature with that in the room.

The rays of heat—like the rays of light from the candle which I have here—are thrown in every direction equally, just as much downwards as upwards, and just as much to the right as to the left.

The special point of interest to us is the effect that the radiant heat has on the air surrounding us. I want you to comprehend clearly that it has *no effect*—it has no direct influence whatever in heating the air. The understanding of this is of great practical value in our study of the subject of heating and ventilation.

This room has air in it, but it is not full, because, by properly pressing it down, we could put in it the air of another room of similar size, and by pressing it more we could add another, and another, and so on until we had got one hundred times as much in it as it at present holds; therefore, we must know that it is not the one-hundredth part full. But now again, if we were to commence at the top, supposing it to be air-tight, of course, and were to remove ninety-nine hundredths of all the air in the room, the remaining one-hundreth part would be evenly distributed over the whole space, so that there would be just as much at the top as at the bottom.

There must, therefore, be some *other* substance or property in the

room besides air, and which has the power of separating the particles of air and keeping them equally apart from each other. And herein we see exemplified another beautiful provision for the universal distribution of the air; so that should man, or any living animal, happen to be confined in a partial vacuum, yet all the air that is there would be equally distributed throughout that space.

Now, suppose we compress our ordinary atmosphere one hundred times; still the individual particles do not touch each other, as otherwise it would become a heavy solid, though it would then only weigh about ten pounds per cubic foot, whereas the same measure of gold weighs more than one thousand pounds. Hence, each individual particle of air must be separated a great many times its own diameter from its nearest neighbor—perhaps, one hundred, or it may be, one thousand times—for any determinate number, in the present state of our knowledge, would be purely conjectural.

Imagine a regiment of soldiers drawn up in line of battle, but instead of standing close together, they were to be posted a thousand times their own diameter, or a quarter of a mile, away from each other—do you not see how many of the enemy's bullets might pass through the line without hitting any one? These individual particles of air, therefore, are so far apart that there is very little probability of the rays of the sun, or the rays from any other hot body, striking them; and I believe it is considered that they are ray-proof, even against the few rays that might happen to hit them.

Though I cannot illustrate this by showing you radiant heat, yet the rays of light were very similar, and I will endeavor to make the effect evident to you by a simple experiment with this candle. I simply place around the candle an opaque cylinder that interrupts the rays of light that are going directly towards you. But why do you not see the column of rays that is passing directly upwards, and which you can see by that small bright spot on the ceiling? To make it more distinct, I will move the light about a little, and you observe the spot of light moves correspondingly.

Now, the *reason* you cannot see that column of light is because the rays move directly on through the intervening space, having nothing to stop them until they get to the ceiling. I say "nothing," because the air is so near nothing that it allows of no perceptible effect; but now let us interpose something that will stop those rays—this piece of paper, for instance, will collect them, by which

the disc of light becomes quite visible—and, of course, being thereby obstructed, they cannot go on to the ceiling. Or, by holding this smoking taper in the path of the rays, there is sufficient solid material in the smoke to obstruct a large portion of those rays, and the column thus illuminated is no doubt plainly visible to all.

So you cannot see the rays of *heat*, but they are passing through the same space, and are very similar, in every way, to the rays of light, the difference in the effect produced being considered due to the difference of velocity with which they move.

That smoke will become *heated* as well as lighted:

Experiments have proved that perfectly pure air, and the gases—oxygen, hydrogen and nitrogen—do not absorb an appreciable amount of the sun's rays, and perhaps if they could be made entirely pure, they might be found to be absolutely ray-proof. But you know that the moisture absorbs a great amount of the heat, because a cloud passing over us of a hot summer's day is an excellent shield from the burning rays of the sun; and there is a large amount of moisture in the air at all times, even when not seen in the shape of clouds.

But you may say, we know that the air does get heated—how is it?

We must again set our imagination to work; we must endeavor to see with our mind's eye those little particles of air, which we at first supposed to be kept constantly separated, and so far apart as scarcely to get within sight of each other, but which, when we come to examine, we find are really clustered together in little groups or families. This we know from the fact, that where we find one atom of oxygen (in the atmosphere), we are sure to find with it four atoms of nitrogen. And again, we find that where these air particles become heated, they are expanded, therefore we must conclude that they are associated together, as just remarked, in little groups or families.

Now, the sun's rays pass through the forty-five miles of atmosphere without heating it, but when they strike the solid substances on the earth's surface the temperatures of the latter are very soon raised. We know this by putting our hand on a board fence, or wall, when the sun is shining on it, or on the curtains or blinds inside of the glass window, which become very much heated by the solar rays.

Last winter I placed a thermometer in a box, lined with black

cloth, and having put a glass over it to keep the wind off, placed it in a snow bank: the mercury soon rose to 180°. We can boil water by the sun's rays even in winter.

When the little groups or families, before mentioned, come in immediate contact with a hot substance, the heat is transmitted to them *by conduction*—each group, so to speak, receiving its "armful" or complement of heat. Being expanded thereby, they are made lighter and forced upward, whilst other particles rush in to take their place; and these latter, as they strike against the hot body, are in turn heated and caused to rise, so that a continuous stream or current is thus created.

As this will be so constantly referred to in our examinations of the heating and ventilation of buildings, and as we ought to be able to comprehend the principle so as to apply it for the regulation of our own health and comfort every hour of the day, I hope you will fully realize that there are two distinct forces constantly acting in opposite directions near every hot fire or other hot substance. One is, the rays of heat passing in every direction *away* from the fire; and the other is the flow of cold air *towards* that fire, and directly in opposition to the rays of heat.

But, that air is not heated at all until it strikes against the hot body itself. The most philosophical way of roasting a turkey, therefore, is to hang it up in front of a hot fire, and use the golden rays of heat to cook it, while the cold, pure, concentrated air is flowing by it into the fire.

Conducted heat has less influence upon us, perhaps, than either of the other systems. As we are affected in this way only by those things that come in immediate contact with us, of course the better or worse conducting power of our clothing has much to do with our comfort.

But *convected* heat is the great curse of the American people. It is that dry, lifeless, withering, debilitating, poisoned stuff with which most of our best houses and public buildings, and, most unfortunately, many of our school houses, too, are filled and warmed; and which is filling our systems, and warming and drying all the life and substance out of about two-thirds of the people of this country.

I have, for the last three or four years, been giving very close attention to the comparative merits of radiant and convected heat.

I formerly supposed that air warmed by a hot water apparatus

was as perfect as any artificial arrangement could be, but more careful recent investigations have shown me my great mistake. Let me first say, however, that hot water is probably the most perfect means of warming what *air* we *must* have warmed.

But what I mean to express, particularly, is, that we should be surrounded with and breathe *cold air*, and receive the *heat* required for the body by direct radiation.

This is just the reverse of what we generally experience in our furnace-heated houses. There we have a little hot, dry air—the air itself being hotter than the temperature of the room, and the walls, especially the windows, colder. No more unscientific, unhealthy and uncomfortable condition could possibly be imagined than this.

Our Creator has provided for a constant difference between the temperature of our bodies and the air with which we are surrounded, for a wise purpose; and we find the greater that difference, the more active and vigorous is the exercise of all our animal functions. As I stated the other evening, there is nearly double the quantity of carbonic acid given off in a temperature near the freezing point that there is in a temperature of °90 or °95.

From this we would argue that when we are breathing air which is near the freezing point, we are twice as active, and can do twice as much work, as when we are breathing air of nearly the temperature of our own bodies. We know how very languid and good-for-nothing we feel on a hot summer's day; and, on the contrary, how fresh and vigorous we feel in the open air of a cold, bracing winter's day, and especially when the glorious golden rays of sunshine come pouring down upon us with all their richness and splendor.

(To be continued.)

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

By Prof. Henry Morton, Ph.D.

(Continued from p. 135.)

We know of no way in which, so satisfactorily, an idea as to the usual character and behavior of sun spots can be given, as by the detailed description of a characteristic specimen, such as was published by the Rev. Mr. Howlett, in the Monthly Notices of the

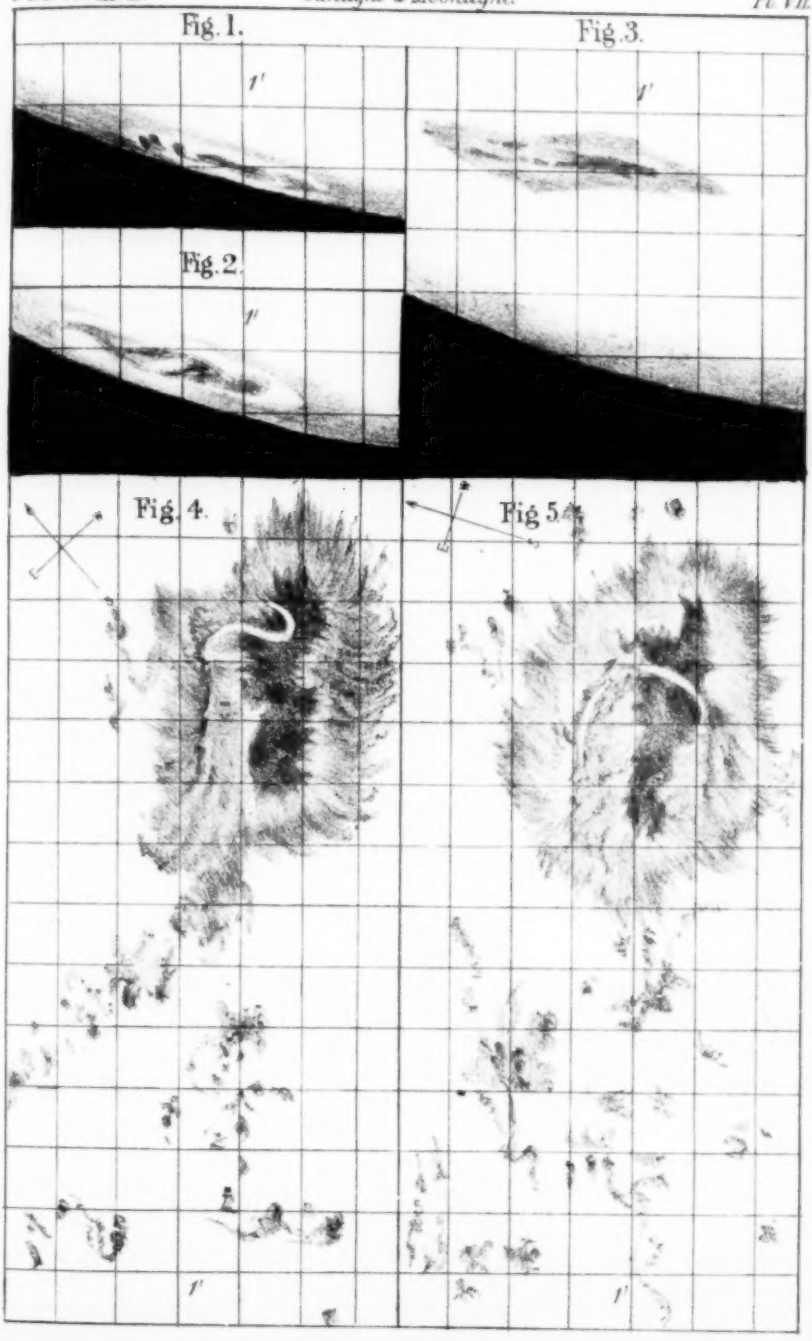


Fig. 1.
Fig. 3.
Fig. 2.
Fig. 4.
Fig 5.

Royal Astronomical Society, November 10th, 1865, Vol. XXVI., p. 13.

We will quote from the description of this eminent astronomer, such passages as will explain the accompanying drawings of a spot which appeared in October, 1865:

"It was first observed by me on the morning of the 7th October last, at 7 A. M., and when not more than about 3″ from the Sun's eastern margin (Fig. 1). It then appeared about 57″ in length from N. to S.; but, in consequence of the extreme effects of foreshortening on the surface of the sphere, only 3″ in breadth from E. to W.

Narrow though the spot, therefore, at this time appeared, yet the positions of the umbræ within it were distinctly visible, and distinguishable from the penumbra in directions of latitude, though I was unable to discern clearly between umbra and penumbra in directions of longitude.

One feature which it struck me as certainly not often to be seen at such an *early* stage of a spot's entry on the disk, was the appearance of two or three luminous patches of faculæ (immediately adjoining the spot on its following side), which extended *completely up to the very margin* of the Sun. * * *

By 2h. 15m. P. M. on the same day (October 7th), the apparent mean breadth of the spot had attained about 7″, and the distance from the limb to the centre of the principal (or western) umbra was 13″ (Fig. 2).

The distinction between umbra and penumbra was now in all parts discernible; and I had at this hour more satisfactory evidence of the *shelving* nature of the sides of a Solar spot than I think ever occurred to me before; for the penumbra on the *following* or *outer* side of the umbra was plainly broader by about 3″ than it was on the preceding or inner side, on which last, in fact, it could not have been much more than 1″ in apparent breadth.

So shallow, however, is the amount always of this shelving, at least in the penumbral strata, and so seldom, comparatively, have I enjoyed the opportunity of observing the entry or departure of a really good-sized spot, furnished at the same time with a neat and really *centrally situated* umbra, that it has only been on two or three occasions, during my six years' experience, that I can fairly assert that I have seen this difference of fore-shortening at all. * * *

On the morning of October 8th the spot had attained a length of

about 76″ by an apparent breadth of about 16″. Its centre was now about 52″ from the Sun's limb; and the penumbra appeared equally wide on both the preceding and following sides of the principal umbra, which lay within the southern portion of the spot (see Fig. 3). * * * *

October 13*th* (Fig. 3). The group this day had attained its most central position on the disk; and as regards size, also, had now reached its utmost dimensions, being about 110″ in length by 60″ still in breadth; and, making every allowance for its oval and also somewhat irregular contour, must have had a superficial area of certainly not less than 972,000,000 square miles. The remaining small spots had a joint area of about 165,000,000 miles; making a grand total of displacement of the solar photosphere to the enormous extent of 1,137,000,000 miles square, or nearly six times that of the whole surface of the earth!

The penumbra on the morning of the 13th was marked by a long dark streak in its northern portion, about 40″ in length and only about 2″ in breadth, which by noon had become more dark and distinct, as if about to become a narrow umbral *rift;* and other shorter streaks lay in nearly parallel lines with it, towards the south-east; whilst another streak from its north-west extremity ran at right angles into the northern side of the umbra, and was divided across by a small bright patch at the hour last mentioned; by which time also a large square projecting portion of penumbral matter had nearly detached itself from the main spot towards the south-east.

But the most remarkable feature, perhaps, this day, was a bright, sharply-defined arch of photospheric matter, about 9450 miles long in its total curve, which floated over the western side of the umbra, and was united at each extremity to the northern side of the penumbra.

I was now also able, as I thought, to discern four separate nuclei in different parts of the great elongated umbra, which feature itself was not less than 26,000 miles in length by 15,000 in breadth; and wherein, towards the south-east, a large triangular mass of the feebly luminous haze was still plainly observable. It is, perhaps, possible that the arch above described was constructed by the union of one of the promontories with the remains of the sigmatoid extension which existed, as we have seen, on October 12th.

By 8 A. M. on October 14th, the great spot presented a very dif-

ferent appearance (Fig. 4). The umbra was completely divided across into two unequal portions by an exceeding bright and nearly straight bridge, 9000 miles long and 1000 miles wide, as before, and which seemed to be formed in part, possibly, out of a modification of the north-west remains of the arch of the day previous. It lay exactly over the principal nucleus of the great umbra, and was considerably dilated at its northern foot. But whether it was that the arch had swung itself loose at its north-east extremity, and then subsequently stretched itself out across the whole width of the umbra, or whether it was an entirely new extension of photospheric matter, I was unable to determine; but subsequent observations have led me to suspect rather the former. * * *

The rift, moreover, was divided by the luminous matter in two or three places, previous to its gradual closing up, as it afterwards proved. Equally curious were certain faint but perhaps not the less important features observable at this time amongst the small subordinate spots that followed in the wake of the principal one. These were evidently diminishing in magnitude, but in their manner of closing up they seemed to betray a noteworthy sort of movement among themselves, or perhaps rather, in the first instance, in the photosphere in which they lay scattered. The largest of these minor spots (which was of the dimensions of about 20″ by 15″) had either drifted away from, or had been left behind by, its principal; whilst at the same time a very peculiar sort of *trailing* arrangement was being assumed amongst themselves, indicating a kind of gyratory movement in the photosphere itself. Many of the little spots had ceased to exhibit any appearance of umbra, but, on the other hand, they had become united more intimately one with the other, by means of a wavy and here and there divaricating thread of penumbral specs running through them; an arrangement this, which may also be distinctly observed in my records, for instance, of 11th May, 1863, and of 1st February, 1864.

On the 15th October I was unable to make a detailed drawing of the group, but I observed distinctly that the great bridge had again become thoroughly curvilinear in its disposition, extending also further up towards the western end of the umbra, and having a total length of a clear 30″ or 13,500 miles. Indeed, in its now modified condition, and as being almost separated, in its new north-eastern portions, from the adjoining penumbra, it might almost be stated as being even 48″, or 21,600 miles long. The rift was also

still plainly to be distinguished, but its more easterly portions had nearly closed up."

In the further history of this spot, until its disappearance round the further limb on the 19th, there is nothing of special interest except that on the 17th the umbra was completely divided by a large mass of penumbra dotted with dusky portions. As is often the case, after the spot had passed out of view, there was seen (Oct. 20th) a conspicuous and dense mass of faculæ, very close to the sun's limb at the point where this spot had disappeared.

On the 3d of November a double spot appeared on the advancing edge of the sun, in the same latitude occupied by the spot just described, and being without doubt the remains of the same, brought round again into view by the solar rotation.

The impression produced by such a series of actions as we have just described, is certainly favorable to the hypothesis that these phenomena are due to displacements of the solar photosphere by violent aerial currents analogous to our terrestrial cyclones accompanied by formation and dissipation of the cloudy matter of the photosphere, such as would be natural under the variations of local temperature which must accompany such action.

Observations of Balfour Stewart and others on the predominance of faculæ on the following side of spots, seem to indicate an upward rush, as gas pushing out the photospheric cloud matter, while, on the other hand, the observations of Lockyer, Father Secchi and others on the shape of the penumbral markings at their edge, &c., seem to indicate an indraught or downward current towards the centre of the spot. May not these observations be reconciled on the assumption that a violent uprush of gas, almost like an explosion, opens out the spot, and that then a subsequent cooling and contraction follows with the production of an inward and downward current, which then continues with a rotary motion as in our whirlwinds and waterspouts? The subject is one of great difficulty and replete with discordant observations, which no theory which has been as yet suggested seems satisfactorily to reconcile. So thoroughly is this the case, that Lockyer, one of the most diligent students of this subject, in his late book on astronomy, declines to give any theory at all.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.

(Continued from Vol. LVI., page 284.)

In contemplating the total field of study, we make the first and grandest distinction to be that of Creature and Creator, a distinction whose truth is sufficiently testified to by the universality of religion in some form.

The creature, so far as spiritual and uncorrupt, can know the Creator through His works, through its own intuitions, and through such communications as the Author of a spirit can, and, as is most natural to suppose, would make to that spirit.

In limiting ourselves, now, to the created universe, we distinguish, for practical purposes, Man and Nature; or, Man and all else that is created.

Man, being conscious both of self and the world, as separate, can make each an object of study.

Each, considered as free, or as uninterfered with by man, is properly said to be studied by *observation*.

Each, as conditioned by human interposition, is said to be studied by *experiment*.

Observation, then, we repeat, is the study of humanly free man and nature.

Experiment is the study of humanly conditioned man or nature.

The results of both observation and experiment, upon both man and nature, may then further be submitted to the exercise of reflection, or may be studied by reflection.

Now, FIRST, in observation of nature, attention is given to the *perceptions*. In observation of self, attention is given to *consciousness*. In experiment, the *imagination* is exercised in devising the conditions to be imposed upon the objects of study. In *reflection*, the powers of *abstraction*, *judgment* and *reasoning* are exercised upon things seen or *remembered*, and the processes of comparison, classification, and generalization are conducted. Thus, in observation, experiment and reflection, the whole *intellectual* being is exercised; and if we include the stimulating motives, and inspiring ends which induce these activities, and remember the body as the instrument

of the spirit, the whole being, without qualification, may be said to be called into action.

SECOND.—Man and nature must be either free or conditioned. There is no third state possible to either.

Therefore, as observation, experiment, and reflection engage the whole being of man upon both himself and Nature, we might conclude that they are the sources of all original human knowledge whatever.

But the guiding distinction at this point is, that Nature and Life are not conditioned by man alone. They are conditioned for man by the Creator, so that the conduct of life presents itself as a series of practical problems for active solution. In other words, in all rational activity, or intelligent practice in the business of life, one is studying, experimentally, the right use of himself under the conditions in which he *finds*, not puts himself; how to develop and wield his powers and opportunities. But, in this form of experiment, the conditions are externally imposed, presented to the man, and not imposed by him. We have, then, an important difference of meaning between the expressions, learning by *experiment*, and by *experience*, or practice.

Whence we conclude that a perfectly composed course of study should provide for study by observation, experiment, reflection and practice.

But of these, reflection is chief, so that the results of observation, experiment, and life experience serve to fully develop or educate the man just in proportion as they are made food for reflection.

This fact demonstrates the impossibility of ranging certain studies exclusively under each head, and thus illustrates the principle mentioned before, that things are distinguished not by the *exclusive* presence of certain attributes, different in each, but by their predominance. Thus, the study of natural history, in its actual specimens, is conspicuously a study by *observation*. But it is by reflection upon the results of observation, and by repeated experimental attempts, that its objects can be properly classified. And again, all those special forms of a general conclusion in geometry, which result from particular suppositions on the given conditions, and which can be determined by inspection, are thereby really learned by *observation*. Also, it is by reflection upon experiments or experience, that the laws of physics and of animal or rational life are determined.

The principles just stated explain why it is that *any* study, thoroughly and fully pursued, can liberally develop the whole man. It is because when, in the familiar expression of *feeling*, we say a man throws his whole being, or goes with his whole soul, into any pursuit, he also does so *literally*—that is, he exercises all his powers on such pursuit, and therefore does broadly, generously, and truly educate himself by it. This also explains a former statement, viz., that the mind thrives best on what it constitutionally likes best.

Nevertheless, and especially when the natural bent of a mind is not very strong, and it seeks, accordingly, development by a prescribed course, such a course may well be composed of such a selection of subjects, as generally and most readily and obviously tends to cultivate each of the several powers of the mind.

We are now prepared to state the idea of truly liberal education. It should be one which, at every stage, affords, 1st, opportunity for study by observation, experiment, reflection, practice; and, 2d, provides various subjects, or exercises, under each head, from which the student can make a selection.

There is, however, an important limitation here to be noted. The world has seen two great civilizations—that is, two which are still visibly operative—the pagan civilization of Greece and Rome, and the modern civilization of the less corrupted portions of Christendom. A large body of men are personally interested, by education and association, in perpetuating systems of education based on the fruits of the former civilization. Another large body of men, now on the stage, and increasing in numbers, think it strange if Christian civilization cannot afford, in the study of free governments, of the broad political economy of the present, of the history, oratory, letters, and noble deeds, and the sciences of modern times, at least as good means of mental development as pagan civilization can, brooded over, as it was, by a crew of disreputable divinities. They claim that it can afford as good or better means. While, therefore, they respect all that is good in the achievements of the past, and would have the knowledge of them, and the culture based upon them, perpetuated so far as is useful in guiding and moulding the present, they believe that systems of education, based upon the two civilizations respectively, are best kept separate; and that, accordingly, it is a mistake to attempt to engraft schools of professional training in modern scientific pursuits upon classical colleges, as is done in several places in this country.

Hardly anything, perhaps, could more effectually defeat the very desirable end of securing graduates of a previous *general* or collegiate course, as students in such professional schools; since there is so great a want of adaptation in a classical course, as a system of preparatory *general* culture, for the *professional* study of modern science.

The last idea suggests one more which we must mention. The idea of a grand all-embracing unity besets and sways many minds. We confess to having once sympathized, more than now, with the idea of an encyclopædic institution, in which everything under the heavens should be taught; and this in behalf of a love for a visible unity. But there can be material unity—that is, essential unity of spirit, purpose, and effort, without formal unity—*i. e.*, uniformity of methods, and concentration of men and means into a single institution. But, nevertheless, formal unity of *some* kind is desirable, and it can be abundantly had by the simple expedient, so harmonious with the usages of the times in other departments of life, of mutual fraternal recognition among all higher institutions, through the agency of local or national associations of their instructors. Such an association, embracing college, and professional school, and academy professors and teachers, already exists in New York State. Similar ones might be formed in other sections, or for the nation at large.

(To be continued)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, January, 16th, 1869.

THE meeting was called to order with the President, Mr. J. Vaughan Merrick, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations received at their stated meeting held January 13th, inst.: from the Zoological Society, the Royal Astronomical Society, the Royal Institution, and the Society of Arts, London, and the Association for the Prevention of Steam Boiler

Explosions, Manchester, England; and l'Ecole des Mines, Paris, France.

The various Standing Committees reported their minutes, and the Special Committee on Revision of the Patent Laws reported progress.

The annual report of the Board of Managers was read by the President, and its publication was directed, by motion.

ANNUAL REPORT FOR 1868 OF THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE.

In accordance with the By-Laws, the Board presents the following report concerning the affairs of the Institute and its operations during the past year.

The number of members and of registered stockholders is as follows:

Number as per last report		1636
Members elected in 1868	113	
Registered Stockholders added	24	
Total added	—137	
Members deceased in 1868	22	
" resigned "	36	
Total	—58	
Nett additions	—	79
Present number		1715

It will thus be seen that the usual annual growth in membership has been maintained.

The condition of the finances, as exhibited in the Treasurer's report, which is herewith submitted, is as follows:

Balance in treasury, January 1st, 1868		$ 1953 54
Receipts during the year		12,804 02
Total		14,757 56
Payments during the year		12,334 34
Balance in treasury, January 1st, 1869		$2423 22

Showing a surplus of receipts over expenditures of nearly $500.

During the year no increase has been made in the funded debt, which remains as per last report, 5 per cent. loan, $11,600.

To meet which there is invested in United States Bonds, bearing interest *in gold*, at 6 per cent., $7000.

Two very successful lectures have been given by the Resident Secretary, at the Academy of Music, illustrated by novel and attractive experiments. To one of these, occurring during the session in this city of the National Board of Trade, an invitation was extended to, and accepted by that body.

Other lectures have been delivered in the Lecture room of the Institute by an efficient corps of Professors, which, by the beauty and novelty of the illustrations, have, besides affording instruction to large audiences, exercised a valuable influence in adding to our memberships. It is proper to remark in this connection, that these lectures have made more apparent the limited facilities afforded by the present Hall for popular instruction in science and the arts. The movement inaugurated in the year 1867, having for its object the appropriation of the "Penn Squares," in this city, to various Societies (of which the Institute was one), for the purpose of erecting thereupon buildings or halls, and to which reference was made in the last annual report, failed to obtain the approval of the Legislature at its last session. It is hoped that during the present session successful efforts may be made to revive and pass this measure.

It is certain, that until new accommodations, in this or some equally suitable locality, be provided, the Franklin Institute cannot accomplish its full measure of utility in promoting the cause of science and the industrial arts.

The Exhibition of American Manufactures, intended to be held during the past year, and for which the City authorities granted the temporary occupancy of one of the Penn Squares, was reluctantly given up, for reasons which appeared to the Board conclusive.

No building of adequate dimensions can be had; and the expense of erecting suitable buildings, for temporary use, on the site above alluded to would have been so great, that the Board did not deem it advisable to incur the risk, especially in view of the then impending Presidential election.

It appears to be desirable that an Exhibition should be held, so soon as accommodations can be obtained for the purpose.

During the past year, the *Journal of the Institute* has been greatly improved, not only by the use of numerous illustrations, but in the nature of its contents, which have been for the most part original.

Its circulation has also so far increased that the cost of publication, now so much higher than formerly, has been nearly covered by the receipts, without any increase in the subscription price.

As its real value, under its present editorial management, becomes more generally known, its publication will prove, as it should, a source of revenue to the Institute.

All of which is respectfully submitted.

By order of the Board.

J. VAUGHAN MERRICK, *President.*

The judges of the election of officers for the ensuing year reported the following gentlemen as duly elected:

President,
J. Vaughan Merrick.

Vice-President,
B. H. Moore.

Treasurer,
Frederick Fraley.

Secretary,
Prof. Henry Morton.

Auditor, Samuel Mason.

Board of Managers,

(For 3 years.)

Charles S. Close, J. S. Whitney, James Dougherty,
John Birkbeck, J. M. Wilson, Robert Briggs,
Washington Jones, Pliny E. Chase,

(For 2 years.)

William Helm.

(For 1 year.)

Caleb S. Hallowell, John H. Towne.

The paper announced for the evening, on the Neva Bridge, at St. Petersburg, by Mr. Joseph Harrison, was then read.

(The report of this paper is not yet ready, but will appear in an early issue.)

The regular monthly report of the Resident Secretary, on Novelties in Science and the Mechanic Arts, was then read, after which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*